

# CEREAL CHEMISTRY

---

VOL. XIII

JULY, 1936

No. 4

---

## RECENT PROGRESS IN CEREAL CHEMISTRY

CLINTON L. BROOKE

Pillsbury Flour Mills Co., Minneapolis, Minn.

(Read at the Annual Meeting, June, 1936)

This paper represents an attempt to select and summarize the most important contributions to cereal chemical literature during the past 12 months (June 1935 to June 1936). As in the survey presented at the Denver Meeting a year ago, papers published in *Cereal Chemistry* are omitted, and no attempt has been made to cover other widely circulated American journals containing material of interest to the cereal chemist.

A valuable and comprehensive review of progress in cereal chemistry during 1935 has been published by Haevecker (1936). An interesting historical summary, giving a broad view of advances in cereal chemistry since 1910, is that of Fairbrother (1935). Natalie Kozmin's book "*Das Problem der Backfähigkeit*" (1936) provides an admirable discussion of the chemistry of bread baking and various factors influencing the baking quality of flour. Particular attention is paid to the work of American cereal chemists in developing the Standard A. A. C. C. Baking Test.

In compiling the following survey, your reviewer has consulted the original papers wherever possible. Considerable material has been drawn from Chemical Abstracts and the abstract sections of the *Zeitschrift für das gesamte Getreide- Mühlen- und Bäckereiwesen*, *Das Mühlenlaboratorium*, and *Chimie et Industrie*.

Of the 105 papers reviewed, 52 are from Germany, 20 from France, 8 from Russia, 7 from England, 5 from Italy, and Hungary, Austria, Holland, Roumania, Japan and Canada are also represented.

### Methods and Apparatus for Testing Flour Strength and Baking Quality

A year ago the reviewer mentioned the studies being carried on by two English investigators, Schofield and Scott Blair, on the physical

properties of doughs, using methods analogous to those employed in the testing of metals. It is interesting to learn that this work is being continued by Halton and Scott Blair (1936) with the co-operation of the Research Association of British Flour Millers, and that very promising results have been obtained in studying the behavior of doughs under actual shop conditions. The authors point out that as early as 1907 Kosutany attempted to measure the physical properties of doughs by pulling out a cylinder of dough at a constant rate and measuring the stress built-up, and that until 1932, when Schofield and Scott Blair (1932, 1933, 1934) began their investigations, work on the physical properties of flour doughs was confined almost entirely to the production of instruments measuring a complex mixture of properties which although in some cases of real value in the bread-making industry, throw little or no light on the physical nature of the problem. It appears that of the various properties measured, the viscosity and the rigidity modulus are of major importance, and that good bread-making quality is associated with a relatively high viscosity and low modulus. The relaxation time, which is the ratio of these two properties, therefore appears to be the chief single criterion of quality.

Another device for testing the physical properties of bread dough is the "tension hystrometer" of Issoglio (1935), which measures the hysteresis of the dough after tension has been applied, and thus affords a measure of the viscosity and modulus of elasticity.

New work on the plasticity of doughs, confirming Bingham's theory of plastic flow, is reported by Volarovich and Samarina (1935), who found that the difference in plasticity constants of different flours is related to their ability to combine with water.

The old question of gliadin-glutenin ratio has been revived by Fleurent (1936), who has developed the theory that the plastic properties of dough are dependent on those of the gluten, and that the latter in turn are dependent on the ratio of gliadin to glutenin, the optimum ratio being 3:1. If the gliadin content is excessive, the dough expands well during fermentation but tends to flatten out in the oven. On the other hand, if the glutenin content is too high, the result is a hard, bucky dough, which does not expand sufficiently during fermentation and baking. Fleurent's investigations of the effect of pH on the plasticity of doughs have led him to conclude that by varying the pH according to the gliadin contents of different glutes, the optimum baking quality can be obtained.

In a paper which includes an interesting discussion of the meaning of baking quality, the purpose of the baking test and the correlation between various quality factors and the baking results obtained by dif-

ferent baking procedures, Berliner (1936) presents extensive data in support of his method of calculating the "theoretical baking quality" of flours from the percentage gluten, gluten swelling number and the maltose figure. He also shows that the properties of commercial flours can be calculated with a high degree of accuracy from the physical and chemical analyses of the component mill streams.

A single-figure estimate of bread-making quality is proposed by Boldescou and Boldescou (1935). This figure is calculated by a formula in which suitable weights are assigned to specific volume, form, color, grain and texture, aroma, flavor and absorption.

Graphical and numerical methods for evaluation of farinograms are compared in a paper by Kopetz (1935), who feels that the so-called Vienna process, in which the potential baking quality is calculated from planimetric measurements which embrace all the properties shown by the curve, is superior to the Hungarian process, in which planimetric measurements of the degree of weakening are combined with the dough-development time and dry gluten content for calculation of the baking quality.

In a study of methods of testing the mill streams, Galter (1936) plots the baking qualities of the streams from wheats of varying strength, and ranks the streams according to baking quality.

Gründer (1935) uses the Fermentograph for determining the fermentation characteristics of the mill streams and points out the possibilities of using these data, together with the percentage distribution, ash content and color figures, in calculating mixtures with the desired reserves of gluten strength and fermenting power, and yet with such high tolerance that they can withstand long fermentation.

A colloid-chemical interpretation of farinography is given by Bungenberg de Jong (1936). According to his theory, the farinogram is a work-time diagram, every point of which represents the sum of the energy processes in play at any given moment during mixing, and tells something about the colloidal properties of the system. Changes in the degree of swelling of the colloids, due for instance to the introduction of electrolytes, are reflected in the change in shape of the curve and a shifting of the more or less clearly defined maxima representing mixing, swelling and adhesion.

Another application of the principles and methods of colloid chemistry to cereal-chemical problems has been made by Kuhlmann (1936). Using Ostwald's filtration apparatus, in which the volume of filtrate can be read at any given moment, Kuhlmann has developed a quantitative method for determining the degree of hydration of the colloids of flour by means of the speed of filtration of a flour suspension prepared by

a standard method. From the curves obtained by plotting volume of filtrate against time, a number of interesting conclusions may be drawn. Determinations on flours from strong and weak wheats indicate a certain relationship between speed of filtration and baking strength. With flours of varying extraction, the speed of filtration increases with increasing extraction. Tests of different sieve fractions of a flour show that the finest fractions filter more slowly and have low water-retaining capacity, due to their high starch content. In a series including flours from other sources than cereals, the sequence according to increasing water-retaining capacity or decreasing speed of filtration was the same as that obtained in earlier work with the dipping refractometer, namely: potato flour, wheat flour, corn flour, rye flour, soy bean flour.

An interesting test for wheat and flour quality has been reported by Potel (1935). Two grams of flour or wheat meal is suspended in 25 cc. of distilled water and 1 cc. of 10% potassium nitrate is added. After 6 hours digestion at 38° C., the suspension is centrifuged, 3 drops of ethyl aldehyde added to 10 cc. of the extract, and the nitrite content is determined colorimetrically by the Griess-Ilosvay reagent. High reducing power indicates inelastic gluten with high extensibility. It is Potel's opinion that the improving action of oxidizing agents is due to a decrease in the reducing power of the flour, resulting in improved gluten quality. Potel has found that the reducing power, determined by this method, is closely related to the dough characteristics shown by the curve of the Chopin Extensimeter. For flours milled from the same wheat, the reducing power increases with length of extraction, because the reductases of the kernel are concentrated in the peripheral layers.

The Göttingen apparatus described in the reviewer's paper a year ago has been modified by Engelke (1935) in such a way that it can be used with very small dough-balls, made with 1 gram of flour or wheat meal.

Another flour testing apparatus in which the changes in water displacement of a fermenting dough-ball are plotted in the form of a curve is described by Hübsch (1936).

The "Fornetograph," another device for recording the expansion of a fermenting dough, is described by Ihlow (1935, 1936, 1936a). The curves obtained before and after punching of the dough give information as to the relative diastatic activity, sugar formation, gas production and retention, gluten quality and baking quality of flours. The apparatus has also given good results in testing the fermenting power of different yeasts and the effect of chemical improvers and diastatic supplements.



The use of the "pneumodynamometer" for testing semolina and flour for absorption, cohesion, consistency, etc., is outlined by DeRege (1935). Information is given concerning the influence of temperature on the physical properties of doughs. The dough is made by adding to the semolina enough 3% salt solution to make a dough containing 42.5% water.

According to Feyte (1935), differences in the mechanical properties of gluten, as measured by the Chopin Extensimeter, are dependent on the pH of its medium, and are partly dependent on its non-nitrogenous content. A substance of unknown chemical nature, which is not removed by ether extraction and which reacts to treatment with sodium sulfite, sodium bisulfide and potassium cyanide gives gluten its physical properties. It appears that cystine and cysteine play an important part in these reactions.

Measurements of oxidation-reduction potentials of flour made by Potel and Chaminade (1935) gave characteristic potentials which were correlated with Extensimeter measurements.

A recording dough mixer which also delivers a sheet of dough of uniform consistency and of the proper thickness for testing in the Extensimeter is described by Chopin (1935). The accuracy of the Extensimeter is considerably heightened through the use of dough-sheets thus prepared.

A method for determining the extensibility of gluten is described by Kranz (1935). Balls made of 2 g. of wet gluten are weighted with 4 gram weights and suspended from hooks at the top of glass tubes 350 mm. long, filled with 2% salt solution at 25°. The length to which the gluten stretches after 2 hours is taken as the extensibility.

In an attempt to determine the approximate size of the colloidal particles in solutions of strong and weak gluten in dilute (0.02 N) lactic acid, Ruemele (1935) passed the solutions through filters of known pore size, and found that the finely dispersed solution of weak gluten, which was expected to pass through the filter readily, was characterized by slow filtration, dependence on the selected pore size, irregular filtration curve with a pronounced maximum, and high clogging factor, while the coarsely dispersed solution of strong gluten, which was not expected to pass through the filter, showed high filtration velocity, independence of the selected pore size, smooth filtration curve and a "gliding" nature during filtration.

Measurements of the electrical conductivity of flour-water pastes have been used by Dedek (1936) as an index of the water-absorbing capacity of flour and also as an approximate index of baking quality; flour of good baking quality showing low, and flour of poor baking quality high conductivity.

Researches on the structure of the flour proteins in relation to their high acid-binding capacity are reported by Reznichenko (1936).

### Enzymes

Work that throws new light on the proteolytic enzymes of flour, their activation by yeast and their inactivation by potassium bromate and other oxidizing agents has just been reported by Jørgensen in "Cereal Chemistry." This work is mentioned here because of its relation to other researches reported in this section.

That chemical improvers indirectly affect other enzymes than proteases is shown by the work of Guillemet and Schell (1936) who found that very small amounts of ammonium persulfate or potassium bromate increase the formation of maltose in dough, probably by preventing the destruction of amylase by the other enzymes of the flour.

Geoffroy and Labour (1934) maintain that although the action of proteases during dough fermentation is not very great, the yeast enzymes have a much greater action on the flour proteins than do the natural enzymes of the flour.

The subject of flour and yeast proteases has also been investigated by Blagoveschenski and Yurgenson (1935), who claim that the effect of the flour proteases is not one of proteolysis but of disaggregation, since there is no increase in amino-nitrogen. The changes in the proteins consist in an increase in the water-soluble fraction and a decrease in gliadin, globulin and glutenin. The effect of the yeast proteases, on the other hand, is a true proteolysis.

Samuel (1935) found that in a dough made with yeast the protein was decomposed about twice as fast as in any dough made without yeast. Because of the utilization of amino-acids by the yeast, however, the amino-acid content of a yeasted dough decreases with time, whereas it increases in an unyeasted dough.

Schmidt (1935) has suggested a simple method for determination of the proteolytic activity of malt preparations. The dough made for the gluten washing test is allowed to stand in a moist atmosphere for 1 hour before washing, and the difference between the specific swelling numbers (by Berliner and Koopman's method) of the glutens washed from treated and untreated flours is used as an index of proteolytic activity. In a later paper Schmidt (1936), proposes using the method for chemical improvers and other supplements as well, and recommends that the dough be allowed to stand 24 hours before washing.

Lemmerzähl (1936) has made use of Schmidt's method in testing a number of commercial malt flours and malt extracts, and has compared the results obtained in determining the diastatic activity of these prod-

ucts by the methods of Lintner and Windisch-Kolbach and the reducing sugar content by the method of Lane and Eynon.

The exact nature of the changes occurring in wheat as the result of heat treatment or conditioning has been the subject of some controversy. Berliner (1935) in a study of wheat conditioning states that proteolysis is of minor importance even in doughs from flours milled from wheat mixtures containing sprouted kernels, and that the wheat kernel contains no proteolytic enzymes comparable in strength to papain, pancreatin, pepsin, trypsin or similar enzymes. It is his opinion that softening of doughs from conditioned wheats is due to excessive starch degradation rather than proteolysis. Apparent increases in diastatic activity and gassing power as the result of conditioning are merely due to physical differences in the flour. Hopf (1935) finds Berliner's claim that dough softening is due to starch degradation to be inconsistent with the fact that starch-free gluten washed from sprouted wheat flour becomes soft and runny upon standing, in the same manner as dough. The decrease in elasticity of gluten during dough fermentation demonstrates gluten degradation. Referring to Ziegler's (1935) curves obtained with the Chopin Extensimeter and the Farinograph, showing the manner in which gluten extensibility can be raised or lowered by conditioning, Hopf points out that the farinogram shows clearly at what temperature the gluten begins to break down under the influence of heat.

Parallelism between the activities of the diastases and proteases of wheat was observed by Schmorl (1935) in studies made with the Farinograph and Fermentograph, and evidence is advanced in support of the theory that the activities of these enzymes also parallel those of oxidases and lipases.

Recent studies on the action of enzymes in baking, including the part played by diastase, the relation of diastatic action to acidity, methods of determining diastatic activity and the proteases of wheat flour are reviewed by Hesse (1935).

Ono (1935) has found that the optimum pH and temperature for the hydrolysis of starch by amylase prepared from yeast by the use of ammonium diphosphate is 6.2-6.6 at 22.5° and 6.0-6.2 at 30°. At pH 6.4 the optimum temperature is 25-30°.

### **Flour Improvers and Bleaching Agents**

Several Hungarian investigators have studied the effect of chemical flour improvers on the nutritive value of flour. Becker and Hangai-Szabo (1936) conducted feeding experiments with rats, using a balanced ration containing flour to which various oxidizing agents were

added in concentrations greatly in excess of those ordinarily used in treating flour. They found no harmful effects when the improvers were added in concentrations 10 times as great as those used in flour, and in most cases no harmful effects when the concentration was 100 times as great. On the other hand, when rats were fed exclusively on flour, either treated or untreated, they developed characteristic A and D avitaminoses, since refined flour contains no appreciable amounts of these vitamins. Their conclusion that no harm results from the destruction of the small amounts of vitamins in flour is somewhat at variance with the conclusions of Darányi and Vitéz (1934) and Vitéz (1935), who also carried out feeding experiments with flour treated with oxidizing and bleaching agents, and found that when rats, mice and dogs were fed exclusively on treated flour, their development was hindered and their state of health harmed, largely because of the destruction of vitamin A, or, rather, carotene. These investigators admit that treatment with oxidizing and bleaching agents does no harm to man with a properly balanced diet, but that the food value of the flour is nevertheless lowered, and they feel that severe harm may be done in the case of a one-sided diet.<sup>1</sup>

Modification of the plastic properties of dough by oxidation and reduction activities is reported by Potel (1935a). Small quantities of hydrogen peroxide increase the tenacity and elasticity of the gluten. Potassium bromate, iodate and chromate, and benzoyl peroxide had unfavorable effects or none on the plastic properties of doughs as measured by the Chopin Extensimeter, while chemicals having an action similar to hydrogen peroxide were sodium perborate, sodium peroxide and ammonium persulfate. A number of reducing substances had a very depressing affect on the Extensimeter results. Gluten washed with very dilute solutions of sodium perborate, persulfate and peroxide had more tenacity and coherence, while when treated with very dilute solutions of sodium thiosulfate, mercuric chloride and potassium cyanide, it lost its cohesiveness. Flour doughs have an oxidation-reduction potential characteristic of a reducing medium.

Methods for the detection and determination of bleaching agents and chemical improvers in flour are reviewed by Radeloff (1935). A method is given for the detection of bromate on the Pekarized flour, using fluorescein as an indicator.

Holtman (1935) has advanced the theory that overbleaching of flour may permit microbial or atmospheric oxidation, causing a darkening of the color.

<sup>1</sup> In weighing these results it should be borne in mind that an exclusive diet of white flour is inadequate in any case, and that all the experimental animals given such a diet eventually developed avitaminoses. Most nutritionists question the validity of survival experiments of this type.—Reviewer.

### Carbohydrates

It appears that French investigators have specialized in research on the carbohydrates during the period covered by this review. The work of Colin and Belval (1934, 1935, 1935a, 1935b) on the glucides of flour and dough indicates that the percentage of sucrose in white flours is not so high as certain authors have reported it, although it is of essential importance at the beginning of the leavening process. The glucides of white wheat flour comprise traces of reducing sugars, a slightly larger percentage of sucrose, and a fructosan (levosin) in sufficient proportions that the alcoholic extract is always levo-rotatory. When flour is deprived of its amylolytic power by sterilizing with boiling alcohol, it gives only 0.15% alcohol on fermentation, a yield which demonstrates the unimportance of preformed fermentable sugars. The germ contains no levosin, small quantities of reducing sugars, a large amount of sucrose and nearly as much raffinose. The bran is particularly rich in sucrose and contains neither levosin nor raffinose. The glucides of rye and barley are about the same as those of wheat. These authors have made the interesting observation that the classification of cereals according to the presence or absence of raffinose in the embryo corresponds exactly to the classification according to the presence or absence of levosin in the albumin and stalks. A further aid in classification is that cereals containing raffinose and levosin elaborate chiefly  $\beta$ -amylase, the others, chiefly  $\alpha$ -amylase. The levosin isolated from wheat and rye flours is not fermented by baker's yeast when in pure solution, but it is hydrolyzed and fermented in bread dough. Geoffroy (1935) isolated 0.2% levosin from wheat flour, and, likewise found that although it is not fermented by baker's yeast, most of it is destroyed during the fermentation of dough.

Genevois and Pavloff (1935) distinguish between two types of sugars in flour: those directly fermentable, such as glucose, fructose, saccharose, and those fermentable only in the presence of a catalyst, the Z factor of Euler and Swartz. Among the latter is maltose, which also is formed by the action of flour amylase on starch. The content of these different types of sugars and the factor Z vary greatly in flours according to their origin, but this is not shown by the usual sugar determination by reduction, which includes all the reducing sugars.

Examinations of wheat flour reported by Geoffroy (1935a) show 0.5% or less of sucrose, less than 1% levosin, and 0.1–0.4% glucose. Here also it is surmised that flour contains a fermentation factor Z or something very similar.

Yet another mention of the Z factor is found in a paper by Guillemet (1935) who states that levosin is slowly attacked in the absence of



Z, but that with it 30% is fermented in 24 hrs. Guillemet (1935a) characterizes the fermentable glucides of flour and dough as fructoholositides, and explains how in fermenting dough the sucrase from the living yeast with fructose forms one third of the supply of fermentable sugars in white flours and in large measure regulates the course of fermentation. The first to ferment are the preformed hexoses and the sucrose and fructose detached from the fructoholositides; the maltose is attacked more and more rapidly.

### Lipids

Working with flours of the same percentage extraction milled from different samples of the same wheat variety, Pelshenke and Schmidt (1935) found a high negative correlation between lipoid content and baking quality. Lipoid content is expressed as the difference between the total fatty material obtained by successive extractions with alcohol and ether and that obtained by ether extraction only. This does not give absolute values, but it affords a convenient relative measure of lipoid content, which is more closely correlated with baking quality, within a given wheat variety, than gluten swelling or dough-ball test numbers. No correlation exists between the average lipoid content and baking values of different wheat varieties.

Data confirming the influence of flour fat on baking were obtained by Ruemele (1935a) in investigations of the chemical and physical properties of washed gluten from a strong and a weak flour, before and after extraction of the fat. It was found that the fat content is a factor which acts against the solution of the gluten, and that removal of the fat increases its solubility.

A rapid method by which the total phosphoric acid in flour can be determined in 3 hours is described by Kocsis and Hegedus (1935). Only one washing and evaporation are involved.

A good tabulation of data on the composition, properties and uses of natural fats, including those of the cereal grains, is presented by Hilditch (1935).

### Ash

An attempt to find a simpler method for replacing the ash determination is reported by Mahlkuch (1935), who measured the turbidity of flour suspensions with various types of turbidimeters, and found that although such measurements may have a certain value for rough control work in the mill, they are not a satisfactory substitute for the ash determination. The best results were obtained when 1% pyrocatechol solution was used to darken the color of the bran particles.

Under present regulations in Germany, the miller is forbidden to

produce flours below certain ash contents, and violations of these regulations are punishable by law. The method developed by Gohlke (1935) for determining whether adulterants, such as phosphates, have been used for artificially raising the ash content of flour, may prove to be of value in other connections. In this method the flour is shaken in a separatory funnel with a mixture of carbon tetrachloride and bromoform having a specific gravity of 2.0, the separated mineral matter is removed, washed again, transferred to a glass filter crucible, washed, dried and weighed.

Strohecker, Vaubel and Breitweiser (1935) have determined the silicic acid content of the different cereals, flour and starch by a colorimetric method which excludes the possibility of contamination with foreign silicates.

New determinations of the percentage composition of the wheat kernel and the ash content of its constituents are reported by Grischenko (1935). A high degree of accuracy is attained by combining the data obtained from dissections of kernels treated with 3% formaldehyde solution, and dry, untreated kernels. On the basis of the ash contents of the flour portions from treated and untreated kernels, suitable corrections were made for the soluble salts transferred from the bran coats by the formaldehyde treatment. For the Russian wheats studied, the percentage of floury material (starchy parenchyma) averaged 82.44% for the soft winter type and 80.85% for the hard spring type, and the ash content of the floury portions averaged 0.29% on the natural moisture basis.

In a study of the ash content of Russian wheats and flours, Knyaginichev (1935) found that the winter varieties contain less ash than the soft and hard spring wheat varieties. The flour of winter wheat contains 25% less ash than that of soft spring wheat. A maximum ash content was found under conditions of sufficient moisture, while ash content decreased in the more arid regions.

### Moisture

A defense of the 130° C. air-oven method for moisture determinations is made by Köster (1936). In a detailed study of the influence of external conditions on the moisture determination in grain and flour, he shows that the 130° C. method with 1 hour drying time is less affected by variations in the temperature and relative humidity of the laboratory and gives results that more closely approach the theoretical moisture content than the 105° C. method with 3-8 hours drying time.

Tucker and Burke (1935) have studied the determination of moisture by distillation with tetrachlorethane and found that the values ob-

tained are usually higher than those obtained by drying at 98.5°. The method is not reliable in the presence of considerable quantities of reducing sugars.

### Storage

A marked difference in the keeping quality of flours from hard red spring wheats grown on fertile black soil and infertile gray soil was observed by Aamodt and McCalla (1935). The flour from most of the samples grown on the black soil retained its baking quality for at least two years after milling, but flour from most of the samples grown on gray soil had deteriorated so much after 10 months storage that it was unfit for breadmaking.

In connection with their extensive studies of the effect of frost on wheat at different stages of maturity, Newton and McCalla (1935) found that the effect of frost was so deleterious to the keeping properties of flour milled from immature wheat that even samples which at first made satisfactory bread became unfit for use after several months' storage.

According to Biéchy (1935) the inferior baking quality of old rye flours is due to a decrease in the heat resistance of the diastase. Using an Ostwald viscosimeter, Biéchy studied the rate of gelatinization of 15% suspensions of rye flours upon slow heating, and found that whereas with young (2 months old) flours the viscosity attained a minimum at 48°, rose to a maximum at 59°, and then fell off rapidly when the temperature was maintained at 60° or further increased; with old flours (1 year) the viscosity continued to rise when the temperature was maintained at 60° or further increased. This difference in rate of gelatinization was not affected by adjustment of the pH of the suspension to 4.75 (the usual pH of sour-dough) or by rapid heating to simulate oven conditions. That the diastase of the old flour was partly inactivated by heating is shown by the fact that the young flour suspension contained 30% maltose after heating, while the old flour suspension contained only 14%. This work indicates that old rye flours with poor baking quality would be considerably improved by the use of diastatic supplements.

In connection with studies of the respiration and heating of hard red spring wheat, Larmour, Clayton and Wrenshall (1935) found that the germination and growth of fungi, which are largely responsible for heating and damage in damp wheat, can be controlled effectively by the vapor of toluene or carbon tetrachloride. In the presence of vapor of these substances, carbon dioxide production is greatly reduced and no heating occurs even in wheat of 25% moisture content. The odor of the vapor disappears upon aeration and air-drying, and prolonged exposure does not injure the quality of the wheat.

A survey of the chemical changes occurring upon aging of food-stuffs, including staling of bread, and the respiration, natural bleaching and ripening of flours has been made by Täufel (1935).

### Pest Damage

Damage to European grain by insects which as yet have not made their appearance in the United States is reported by Schulze (1935, 1935a). The so-called "wheat-bugs" (*Eurygaster integriceps* and *maura*, *Aelia rostrata* and *acuminata*) attack the kernel in the milk-ripe stage, depositing a substance which so disintegrates the gluten that the flour is unfit for baking purposes. As little as 3% of damaged kernels suffices to impair the gluten and baking quality of the flour. Wheat thus damaged is known as "Leimkleberweizen," which may be translated "slimy gluten wheat." Although the exact nature of the damage done to the gluten is not definitely established, a number of investigators believe that the substance deposited by the bug contains proteolytic enzymes. This would explain Kranz' (1935a) finding that flour from wheat damaged by wheat-bugs can be improved by treatment with bromate and that even better results are obtained when the wheat is conditioned at high temperatures (up to 50°) and high moisture content (up to 20%) and the resulting flour is treated with bromate. Tests made by Mohs and Klemm (1936) support the theory that the damage is due to proteolytic enzymes, and indicate that diastatic enzymes also are deposited in the kernel by the "sting" of the bug.

Less serious damage is done by the larvae of a species of owl moth (*Hadena basilinea*), which feed on the kernels while still in the head and damage them in somewhat the same manner as the granary weevil. Kernels damaged by the owl moth larvae can readily be distinguished from those damaged by the granary weevil when examined under ultraviolet light, since the weevil-damaged kernels show a lively, bluish-white fluorescence, arising from excreta absorbed by the floury portion.

An experimental apparatus for testing the toxicity of gaseous fumigants to the granary weevil and other insects under varying conditions of temperature, time and concentration is described by Peters and Ganter (1935). Curves are given showing the concentration and time required for a 100% kill with HCN and ethylene oxide at different temperatures.

### Grain Conditioning

Present knowledge of grain conditioning is well summarized in a special number of "Die Mühle." The present trend is toward high temperatures, and it appears that there no longer is any doubt about the improvement effected in milling and baking quality, although the

causes of the improvement, especially that in gluten quality, are still a matter of controversy. Gehle (1935), Annen (1935), Berliner (1935), Haltmeier and Hopf (1935a) in their several papers discuss the nature of hard and soft wheat conditioning and the improvements obtained. Haltmeier (1935a) describes an electrical experimental conditioner and Annen (1935) outlines results obtained with this apparatus at temperatures ranging from 40° to 60° C., showing a linear increase in gluten swelling number and gluten shortening with increasing temperature. Kettner (1935) describes a combined grain peeling and conditioning apparatus, which, he claims, results in flour of improved yield, keeping quality and color, and bread of superior aroma and flavor. Sound flour can be produced from musty grain, since the outer layers of the kernel are entirely removed.

The effect of high temperatures on biochemical changes in wheat was investigated by Kretovich and Riazantzeva (1935). Denaturation of gliadin was increased and the hydration of gluten markedly decreased by heating to 90–130° C. Diastatic activity increased decidedly at 60–90° C. Catalase activity falls off rapidly on heating to 90° C. even with quite dry grain, and it is suggested that control of grain-drying and high-temperature conditioning could be based on the determination of catalase activity.

Problems arising in the mixing of strong and weak wheats or flours are discussed by Hopf (1935b). Unless the dough-development time of the hard wheat is shortened to equal that of the soft wheat, the farinogram will show two different dough-development times, and the dough will stiffen during fermentation, resulting in a small, compact loaf. Shortening of the dough-development or mixing time of hard wheats can be accomplished only by warm conditioning at high moisture content. Where the hard and soft wheats are ground separately and conditioning facilities are not available, the dough-development time of the hard wheat can be shortened by finer grinding.

Results obtained in high-temperature conditioning of various types of wheat used in England are described by Ward (1936). Using a laboratory hot-air conditioner a marked improvement was effected in the milling and baking properties of wheats conditioned at temperatures of 150–160° F.

### Experimental Milling

Kranz (1935b) describes a simple experimental mill for 3 kilogram wheat samples. The mill has a double stand of rolls, one pair corrugated and the other smooth, and a two-section plansifter with six sieves in each section. Three breaks and three reductions are employed, the roll settings being standardized by means of a scale and pointer. To



prepare a flour of 60% extraction (on the basis of the wheat) the flours from the three break grindings and the first two reductions are combined and weighed and enough of the flour from the third Reduction is added to give a total extraction of 60%. The same procedure is followed in grinding to a constant ash of 0.55% (on the moisture-free basis), except that the ash contents of the five combined flours and the flour from the third Reduction must be determined before the required amount of the latter can be calculated. If two grades of flour are desired, a patent is made by combining the 2nd Break flour and enough of the 1st Reduction flour to give an approximate yield of 20%. In making up the clear, enough of the 3rd Reduction flour is held out to give an approximate yield of 40%.

A somewhat longer experimental milling system, with 4 breaks and 4 reductions, but operated on the same principles as the above, is outlined by Barbade (1934).

Hopf (1935c) presents farinograms and fermentograms of flours milled from uncleaned wheat and the same wheat after aspiration and scouring, showing that the stability and gassing power of the flour are appreciably increased by thorough cleaning of the wheat. In an investigation of the effect of tempering with water upon the strength and gassing power of rye flours, Hopf (1935d) found that tempering with 1.5% water caused a slight impairment in strength and a marked falling off in gassing power in the fourth hour of fermentation.

### Bread Flavor

The flavor of bread is the subject of a paper by Pelshenke (1935), who shows that the principal factors influencing flavor are time, temperature, rate, duration and nature of fermentation; baking temperature and time; type of flour and type of loaf.

Obst (1935) reviews German researches on bread flavor and refers to the work of the Hamburg Laboratory for Milk Bacteriology in developing strains of bacteria which produce considerable quantities of acetylmethylcarbinol during fermentation. The acetylmethylcarbinol thus formed is stable and is not oxidized to diacetyl during the baking process.

Maiden (1936) raises the question whether it is justifiable to consider aroma and flavor as one and the same thing. A good flavor is often accompanied by a good aroma, but they are not identical. Maiden has made numerous experiments with acetylmethylcarbinol and diacetyl, and concludes that while both substances give bread a definite flavor, it is not a true bread flavor, but a foreign one.

### Particle Size

A novel method of determining the approximate particle size of flours is suggested by Witte (1936). A small amount of the flour to be tested is mixed with an equal quantity of fine coal dust of known fineness and blackness, and the percentages of white and black in the mixture are measured by means of the Leukometer. The results are expressed in terms of specific surface area or average size of particles.

A mathematical treatment of the distribution of particles in finely-divided materials according to size and specific surface is given by Rosin and Rammner (1935). Various methods of determining particle size are reviewed, and practical applications in the milling industry, such as determining the wear on stocks in passing through conveyors, the degree of unmixing of stocks made up of particles of widely different dimensions, and the efficiency of grinding, are suggested.

### Microscopical Methods

Methods for indirect microscopical identification of aleurone particles in flour by means of dyes which in alkaline solution give characteristic color reactions with the magnesium compounds contained in the globoids have been devised by Broda (1935). The colored globoids are easily distinguishable under low magnification and afford an index of the number of aleurone particles present, and hence of the approximate grade of the flour.

Microscopic examinations of flours from ripe and unripe wheat kernels have been made by Schmorl (1936), who found that whereas in ripe kernels the ratio of large to small starch granules was 1:4.8, in unripe kernels the ratio was 1:10.8. He concludes that the poor baking quality of many wheats having a high ratio of small to large starch granules may be due to insufficient ripeness.

A microscopic method for detection of as little as 1% of rice in wheat flour is given by Tuffi and Borghetti (1935). Upon application of equal parts of 0.2% methylene blue and 0.1% eosin A, the rice flour is dyed a greenish-blue with groups of violet-tinted granules, whereas the wheat flour remains colorless or is dyed a pale blue, while the proteins are dyed violet.

Measurements of the thickness of the walls of the aleurone cells of wheat and rye have been made by Grünsteidl, Fromm and Bauer (1935), who report a thickness of 4-5  $\mu$  for Austrian wheats and 4.5-5.5  $\mu$  for ryes. The transverse walls are somewhat thinner than the longitudinal walls. The thickness of the cell wall is primarily a varietal characteristic, but is also influenced by climatic conditions.

### Miscellaneous

New work on Strohecker's method for determining the composition of rye and wheat flour mixtures has been done by Werner and Volger (1935), who find that whereas the trifructosan content of wheat flours is practically constant, that of rye flours varies within such wide limits that the composition of mixtures can be determined only where the trifructosan content of the rye flour in the mixture is known. So much of the trifructosan is lost during the baking process that it is impossible to determine accurately the proportions of rye and wheat flours in baked goods.

Complete analyses and *in vitro* digestibility coefficients for 30 German wheat and rye breads are given by Peyer and Gruschwitz (1935). The analytical methods employed are described in detail.

Methods for the evaluation of macaroni and other alimentary pastes by boiling in a dilute salt solution are described by Borasio (1935). The factors determining quality are degree of cooking, resistance to disintegration, water-absorption capacity and increase in volume.

Seidel (1935) proposes spraying the entire surface of the baked loaf with a 3-5% solution of acetic acid before wrapping in waxed paper, in order to prevent the growth of molds.

Kühl (1936) outlines various methods for determining whether flours are of the same origin, *i.e.*, milled from the same wheat. When the flours are of different degrees of extraction, as indicated by the ash content and Pekar color, the most valuable indication of identity of origin is similarity of the various groups of micro-organisms developing in cultures incubated for 24-48 hrs. For flours of the same degree of extraction, the chief criteria are titrable acidity, elasticity and extensibility of gluten, microscopic appearance of the starch, rate of filtration and turbidity of the aqueous extract, biuret reaction, and nitric acid flocculation reaction.

Nottbohm and Mayer (1935), who previously have reported studies of the phosphatides of wheat flour, have made similar studies of the phosphatides of bran. They find that wheat bran contains approximately 0.35% betaine. Apparently the betaine is not involved in the building up of the bran phosphatide.

The inorganic and phospho-organic constituents of wheat embryo are reported in analyses given by Zunini (1935).

### Literature Cited

Aamodt, O. S., and McCalla, A. G.

1935 Quality and keeping properties of flour from wheat grown on the black and gray soils of Alberta. *Can. J. Research* 13: Sec. C: 160-7.

Annen, Herman

1935 Der heutige stand der konditionierung. *Mühle* 72: 1031-4.

- Barbade, P.  
1934 Laboratory milling to evaluate the baking qualities of wheat. *Ann. fals.* **27**: 476-85. (C. A. **29**: 846.)
- Becker, E., and Hangai-Szabo, B. V.  
1936 The effect of chemical flour improvers on the animal organism. *Mezőgazdasági Kutatások* **9**, No. 2. (Mühlenlab. **6**: 63.)
- Berliner, Ernst  
1935 Ueber hart- und weichweizenvorbereitung und ihre kontrolle. *Mühle* **72**: 1033-6.  
1936 Ueber qualitätsprüfung von weizen und weizenmehlen. *Mühlenlab.* **6**: 49-62.
- Biéchy, Theodor  
1935 Einfluss des mehlalters auf den verkleisterungsverlauf beim roggenmehl. *Mühlenlab.* **5**: 129-40.
- Blagoveschenski, A. V., and Yurgenson, M. P.  
1935 The changes of wheat protein under the action of flour and yeast enzymes. *Biochem. J.* **29**: 805-10.
- Boldescou, George, and Boldescou, Silvia  
1935 Eine neue methode zur deutung der faktoren, die zur entwicklung der verbrodungsfähigkeiten der mehle beitragen. *Z. ges. Getreide-Mühlen- Bäckerei.* **22**: 195-7.
- Borasio, L.  
1935 Cooking macaroni. *Giorn. risocultura* **25**: 251-7. (C. A. **30**: 2656.)
- Broda, Boleslav  
1935 Mikroskopischer nachweis von aleuronkörnern im mehl durch färbung. *Z. Untersuch. Lebensm.* **70**: 470-3.
- Chopin, Marcel  
1935 Pétrin enregistreur et extracteur de pâtes. *La Meunerie Française* **51**: 276-80.
- Colin, Henri, and Belval, Henri  
1934 The glucides of cereals. Levosin and raffinose in grains and flour. *Congress chem. ind. Paris, Oct., 1934.* (C. A. **29**: 5933.)  
1935 Glucides of flour and of dough. *Compt. rend.* **200**: 2032-4. (C. A. **29**: 5524.)  
1935a The levosin of cereals and flours. *Bull. soc. chim. biol.* **17**: 1040-4. (C. A. **29**: 6654.)  
1935b Sugars of flour and dough. *Bull. soc. chim.* (5), **2**: 1907-12. (C. A. **30**: 1447.)
- Darányi, J. von, and Vitéz, St. von  
1934 Tierexperimentelle untersuchungen über die wirkung von mehlbehandlungsmittel. *Z. Untersuch. Lebensm.* **68**: 597-612.
- Dedek, Jaroslav  
1936 Electrical conductivity of flour pastes. *Bull. assoc. chim.* **53**: 249-52. (C. A. **30**: 3532.)
- DeRege, F.  
1935 The physical-chemical characteristics of flour. *Giorn. risocultura* **25**: 109-18, 132-42, 174-80, 204-13. (C. A. **30**: 1130.)
- Engelke, Heinrich  
1935 Die bedeutung der mikromethoden zur feststellung der weizenqualität nebst beschreibung einer neuen mikromethode. *J. Landw.* **83**: 89-106.
- Fairbrother, Thomas H.  
1935 Cereal chemistry. *Milling* **84**: 430-2, 435, 438.
- Feyte, A.  
1935 Nitrogenous matter of wheats and flours. *Ann. agron. (N. S.)* **5**: 72-88. (C. A. **30**: 169.)
- Fleurent, E.  
1936 Contribution a l'étude physique et chimique de la panification. *Chimie & Industrie* **35**: 507-19.
- Galter, Eberhard  
1936 Grundsätzliches über passagenprüfung. *Mühlenlab.* **6**: 1-12.
- Gehle, Heinz  
1935 Getreide-Vorbereitung. *Mühle* **72**: 1027-30.

- Genevois, L., and Pavloff, M.  
1935 Fermentable sugars of wheat flour. *Compt. rend.* **200**: 690-2. (Mühlenlab. **5**: 80.)
- Geoffroy, R.  
1935 Action de la levure haute sur la lévosine en solution et dans les pâtes les boulangerie. *Bull. Soc. Chim. Biol.* **17**: 848-51.  
1935a Glucides fermentescibles des farines de froment et fermentation panaire. *Bull. soc. chim. biol.* **17**: 1351-71.  
— and Labour, G.  
1934 Action of proteolytic enzymes on the proteins of wheat flour. *Bull. soc. chim. biol.* **16**: 1625-30. (C. A. **29**: 1890.)
- Gohlke, Bruno  
1935 Ueber eine methode des quantitativen nachweises von mehlverfälschungsmitteln, die zur künstlichen erhöhung des aschegehaltes der mehle verwendung finden. *Z. ges. Getreide- Mühlen- Bäckereiw.* **22**: 227-30.
- Grischenko, Anna P.  
1935 Das verhältnis der bestandteile des weizenkornes und ihr aschegehalt. *Mühlenlab.* **5**: 181-8.
- Gründer, W.  
1935 Kennzeichnung der mehle nach "Backfähigkeit," ein beitrag zur problematik der triebkurven von passagenmehlen. *Mühlenlab.* **5**: 73-8.
- Grunsteidl, E., Fromm, E., and Bauer, F.  
1935 Studien über das aleuron und seine ausnützung. I. Morphologische Vergleiche der Aleuronzellen von Weizen und Roggen. *Mühlenlab.* **5**: 81-90.
- Guillemet, R.  
1935 The catalytic fermentation of some fructoholositides. *Compt. rend.* **201**: 1517-19. (C. A. **30**: 2594.)  
1935a The fermentable glucides of flour and dough. *Compt. rend. acad. agr. France* **21**: 889-92. (C. A. **30**: 526.)  
— and Schell, C.  
1936 Action of some oxidants on amylosis and alcoholic fermentation in wheat flour dough. *Compt. rend. soc. biol.* **121**: 463-4. (C. A. **30**: 3533.)
- Haevecker, H.  
1936 Fortschrittsbericht 1935. *Z. ges. Getreide- Mühlen- Bäckereiw.* **23**: 24-7, 43-52, 69-73.
- Haltmeier, Otto  
1935 Die feststellung der konditionierwirkung. *Mühle* **72**: 1037-40.  
1935a Ein elektrischer Versuchs-Konditionerapparat. *Mühle* **72**: 1029-32.
- Halton, P., and Scott Blair, G. W.  
1936 A study of some physical properties of flour doughs in relation to their bread-making qualities. *J. Phys. Chem.* **40**: 561-80.
- Hesse, Albert  
1935 The use of enzymes in industry. II. Recent studies on the action of enzymes in baking. *Ergebnisse Enzymforsch.* **4**: 147-72. (C. A. **29**: 4841.)
- Hilditch, T. P.  
1935 The fats. *Chemistry & Industry*, 1935, 139-45, 163-7, 184-9.
- Holtman, D. Frank  
1935 The microbial content of soft wheat flour. *J. Bact.* **30**: 359-61.
- Hopf, Leo.  
1935 Konditionierung. *Mühle* **72**: 1129-32.  
1935a Konditionieren von gestern und heute. *Mühle* **72**: 1039-44.  
1935b Weizenmischungen und gemischte Mehle. *Mühle* **72**: 611-13.  
1935c Untersuchungen über den einfluss der reinigung auf die backfähigkeit des weizens. *Mühle* **72**: 967-8.  
1935d Welchen einfluss hat das netzen auf die backeigenschaften von rogenmehl? *Mühle* **72**: 273-4.
- Hübsch, O.  
1936 Prinzip und konstruktion eines mehlprüfapparates. *Mühlenlab.* **6**: 27-30, 38-42.



Ihlow, Fr.

1935 Erfahrungen mit dem mehqualitätsschreiber "Fornetograph." Z. ges. Getreide- Mühlen- Bäckerei. **22**: 187-91; Mehl und Brot **35**: No. 44, 2-5.

1936 Hefequalitäts-Prüfung im Fornetograph. Mehl und Brot **36**: No. 1, 2-4.

1936a Der Fornetograph in der Mülerei. Mühlenlab. **6**: 65-74.

Issoglio, Giovanni

1935 The physicommechanical properties of bread doughs. Ann. chim. applicata **25**: 274-92. (C. A. **30**: 1131.)

Jong, de H. L. Bungenberg

1936 Wesen und deutung der farinographie im kolloidchemischen Sinne. Mühlenlab. **6**: 23-8.

Kettner, Otto

1935 Kombiniertes getreideschäl und vorbereitungsverfahren. Mühle **72**: 1043-6.

Knyaginichev, M. I.

1935 Varietal differences of wheats with reference to the ash content in grain and flour. Bull. Applied Botany, Genetics, Plant Breeding (U. S. S. R.), Ser. III, No. 5, 169-201. (C. A. **30**: 776.)

Kocsis, E. A., and Hegedus, I.

1935 Bestimmung des gesamtposphorgehaltes der mehle. Z. Untersuch. Lebensm. **70**: 474-5.

Kopetz, L.

1935 Graphische oder zahlenmässige auswertung von farinogrammen? Mühlenlab. **5**: 97-102.

Köster, Alfred

1936 Der einfluss, äusserer bedingungen auf die feuchtigkeitsbestimmung von getreide und mehl. Z. ges. Getreide- Mühlen- Bäckerei. **23**: 35-43.

Kozmin, Natalie P.

1936 Das problem der backfähigkeit. Moritz Schäfer Verlag, Leipzig.

Kranz, W.

1935 Kleberdehnbarkeit. Mühlenlab. **5**: 161-6.

1935a Ueber das auftreten der weizenwanze bei der ernte 1935. Mühlenlab. **5**: 177-82.

1935b Vereinfachte versuchsmüllerei zur weizenqualitätsprüfung. Mühlenlab. **5**: 101-4, 125-6.

Kretovich, V. L., and Riazantzeva, E. M.

1935 Biochemical changes in grain under the action of high temperatures. Compt. rend. acad. sci. U. R. S. S. (N. S.), **3**: 409-12. (C. A. **30**: 1445.)

Kühl, Hugo

1936 Verfahren zum nachweis der gleichen herkunft von weizenmehlen. Mühlenlab. **6**: 73-8.

Kuhlmann, A. G.

1936 Die Filtrationsanalyse nach Wo. Ostwald als neue Methode der Bewertung des Mehls. Z. ges. Getreide- Mühlen- Bäckerei. **23**: 64-9.

Larmour, R. K., Clayton, J. S., and Wrenshall, C. L.

1935 The respiration and heating of damp wheat. Can. J. Research **12**: 627-45.

Lemmerzähl, J.

1936 Untersuchungen an malzmehlen und malzextrakten für die Bäckerei. Z. ges. Getreide- Mühlen- Bäckerei. **23**: 58-64, 85-9.

Mahlkuch, Ernst

1935 Versuche über den ersatz der aschebestimmung durch einfachere Methoden. Z. ges. Getreide- Mühlen- Bäckerei. **22**: 230-2.

Maiden, A. M.

1936 A system of judging flavor in bread. J. Chem. Ind. **55**: 143-145. Milling **86**:

Mohs, Karl, and Klemt, G.

1936 Ueber die backfähigkeit von leimkleberweizen. Z. ges. Getreide- Mühlen- Bäckerei. **23**: 1-7.

Newton, R., and McCalla, A. G.

1935 Effect of frost on wheat at progressive stages of maturity. III. Milling and baking quality. Can. J. Research **13**, Sec. C: 263-82.

- Nottbohm, F. E., and Mayer, F.  
1935 Ueber das vorkommen von betain in weizenkleie. *Z. Untersuch. Lebensm.* **69**: 289-300.
- Obst, Walter  
1935 Deutsche forschungsarbeit über das brotaroma. *Mehl und Brot* **35**, No. 47, 1-2.
- Ono, Kazuki  
1935 Yeast amylase. II. Enzyme-chemical properties. Optimum pH and temperature. *J. Agr. Chem. Soc. Japan* **11**: 803-7.
- Pelshenke, P.  
1935 Ueber den geschmack des brotes. *Mehl und Brot* **35**, No. 22, 1-3.  
— and Schmidt, E.  
1935 Einfluss des lipoidgehaltes auf die backfähigkeit bei weizen und weizenmehlen. *Z. ges. Getreide- Mühlen- Bäckerei.* **22**: 119-22.
- Peters, G., and Ganter, W.  
1935 Kornkäferbekämpfung mit blausäure und aethylenoxyd. *Z. ges. Getreide- Mühlen- Bäckerei.* **22**: 122-31, 140-5.
- Peyer, W., and Gruschwitz, K. H.  
1935 Untersuchungen über beschaffenheit und zusammensetzung des deutschen, insbesondere des schlesischen brotes mit besonderer berücksichtigung der verdaulichkeit der stickstoffsubstanz in vitro. *Z. ges. Getreide- Mühlen- Bäckerei.* **22**: 37-41, 54-60, 73-80, 96-8, 110-12.
- Potel, Pierre  
1935 Importance du pouvoir réducteur des blés et farines dans l'appréciation de leur qualité. *Compt. rend. acad. agr. France* **21**: 116-19.  
1935a Recherches sur certaines propriétés physico-chimiques des blés et des farines. *Ann. agron. (N. S.)* **5**: 690-703.  
— and Chaminade, Raymond  
1935 Oxidation-reduction potentials of flour. *Compt. rend.* **200**: 2215-17. (*C. A.* **30**: 3532-3).
- Radeloff, H.  
1935 Bleichung und backfähigkeitsverbesserung der mehl und die methoden zu ihrem nachweis. *Z. Untersuch. Lebensm.* **70**: 169-80.
- Reznichenko, M. S.  
1936 Neue ergebnisse der eiweissforschung und ihre bedeutung für die mehlchemie. *Mühlenlab.* **6**: 35-8.
- Rosin, P., and Rammner, E.  
1935 Feinheitsskenngrößen von gekörnen, insbesondere von staub. *Mühle* **72**: 1523-6, 1557-8, 1589-91.
- Ruemele, Th.  
1935 Die Größenordnung der weizenkleberteilchen im kolloiden zustande. *Z. Untersuch. Lebensm.* **69**: 453-8.  
1935a Ueber das mehl fett. *Z. Untersuch. Lebensm.* **69**: 355-63.
- Samuel, Leslie W.  
1935 The amino acid content of wheat-flour dough. *Biochem. J.* **29**: 2331-3.
- Schmidt, A.  
1935 Die bestimmung der proteolytischen wirkung von malzpräparaten. *Z. ges. Getreide- Mühlen- Bäckerei.* **22**: 138-40.  
1936 Wirkung von zusätzen zu mehl und teig auf den kleber. *Mühlenlab.* **6**: 17-24.
- Schmorl, Karl  
1935 Ueber den parallelismus der fermente im getreide (Weizen). *Z. ges. Getreide- Mühlen- Bäckerei.* **22**: 101-4.  
1936 Studien über reifevorgänge am brotgetreide (Wz.). *Mühlenlab.* **6**: 11-15.
- Schofield, R. K., and Scott Blair, G. W.  
1932-33 The relationship between viscosity, elasticity and plastic strength of a soft material as illustrated by some mechanical properties of flour doughs. I. *Proc. Roy. Soc. A*, **138**: 707-18 (1932); II, **139**: 557-66 (1933); III, **141**: 72-85 (1933).  
1934 Apparatur zur Bestimmung der mechanischen Eigenschaften von Mehlteigen in absoluten Einheiten. *Mühlenlab.* **4**: 41-6.

- Schulze, Konrad  
1935 Wissenswertes von der "Weizenwanze." Z. ges. Getreide- Mühlen- Bäckerei. **22**: 211-18.
- 1935a Starker queckeneulenfrass an diesjährigem deutschen getreide. Z. ges. Getreide- Mühlen- Bäckerei. **22**: 185-6.
- Seidel, Kurt  
1935 Untersuchungen über die verhütung des schimmelns der brote. Mehl und Brot **35**, No. 25, 1-5.
- Strohecker, R., Vaubel, R., and Breitweiser, K.  
1935 Ueber den gehalt der einzelnen getreidearten, der mehle und der stärke an kieselsäure. Z. ges. Getreide- Mühlen- Bäckerei. **22**: 131-3.
- Täufel, K.  
1935 Zur frage des alterns der lebensmittel. Forschungen u. Fortschr. **11**: 321.
- Tucker, J. M., and Burke, T. E.  
1935 Determination of moisture in cereals by distillation with tetrachlor- ethane. Analyst **60**: 663-7.
- Tuffi, Riccardo, and Borghetti, Elena  
1935 Detection of rice in wheat flour. Ann. chim. applicata **25**: 351-4. (C. A. **30**: 1130.)
- Vitéz, István  
1935 Animal experimental investigations of the action of flour-treating agents. II. Effect on the vitamin of flour and on the animal organism when bread is fed exclusively. Z. Untersuch. Lebensm. **70**: 258-65. (C. A. **30**: 1130.)
- Volarovich, M. P., and Samarina, K. I.  
1935 Viscosity and plasticity of disperse systems II. The plastic properties of dough by the rotating-cylinder method. Kolloid- Z. **70**: 280-5. (C. A. **29**: 6655.)
- Ward, Horace  
1936 Conditioning, the process, the methods and the object. Milling **86**: 409-12.
- Werner, W., and Volger, H.  
1935 Nachweis von roggenmehl und weizenmehl in mehlmischungen mit hilfe des trifruktosan-Gehaltes. Z. Untersuch. Lebensm. **69**: 555-62.
- Witte, Martin  
1936 Schnellbestimmung der korngrösse von Weizenmehl. Mühlenlab. **6**: 33-6.
- Zeigler, Edwin  
1935 Einfluss der konditionierung auf die dehnbarkeit des weizenteiges. Mühle **72**: 1035-8.
- Zunini, Enrico  
1935 Wheat embryo. The inorganic and phospho-organic constituents. Chim. ind. agr. biol. **11**: 339-42.

## ELASTICITY OF WHEAT FLOUR DOUGH<sup>1, 2</sup>

L. J. BOHN and C. H. BAILEY

Division of Agricultural Biochemistry, University of Minnesota, St. Paul, Minnesota

(Received for publication November 29, 1935)

Flour dough is a plastic solid and much information is available from the fields of physics, mechanics, and metallurgy as to the nature of such systems. The whole process of making bread is a mechanical one and it is the physical properties of dough as it enters the oven, as well as aeration, which determine to a large extent the quality of the loaf of bread. Any work relating the chemical and physical properties of dough should, therefore, prove useful in helping to determine the numerous factors that affect the quality of a loaf of bread.

Numerous attempts have been made to evaluate the bread and cake baking quality of flour by physical measurements made upon flour suspensions, doughs, and wet crude gluten washed from flour dough. These include viscometric studies as well as physical tests applied to washed gluten and to flour doughs.

Bailey and Le Vesconte (1924), and Bailey (1925) have described some of the instruments used to test the physical properties of flour dough and gluten. No attempt will be made to review all the literature on this subject. Some of the instruments described, however, are of special interest to the work undertaken in this investigation.

Rejtö (1907) devised a mechanical apparatus whereby he stretched a square test piece of dough to increasing lengths and charted the force or stress required to produce the extension.

Hankoczy (1907) designed a device to test the ductility and extensibility of wet crude gluten in a direct manner. Gluten was clamped between two plates with orifices. Air was introduced from one side and the gluten was stretched and expanded into a bubble through the perforation in the opposite plate. Hankoczy considered the baking strength of the flour to be related to the volume of the bubble and the pressure which the bubble would maintain.

Kress (1924) clamped gluten between two discs having an 18 mm. orifice in the centre of each. The gluten was compressed to a thickness

<sup>1</sup> Paper No. 1393, Journal Series, Minnesota Agricultural Experiment Station.

<sup>2</sup> Condensed from a thesis presented to the Graduate School of the University of Minnesota by Leonard J. Bohn in partial fulfilment of the requirements for the degree of Doctor of Philosophy, July, 1935.

of 3 mm. and a force of increasing magnitude was applied by a plunger 12 mm. in diameter, acting through the orifice. The distance the gluten could be stretched before breaking was found to be correlated with baking tests. The Bühler Comparator is similar in principle, but works on dough instead of gluten.

Chopin (1927) described an instrument to be used with doughs consisting of two plates with a large orifice on top and a smaller one below. The bottom plate had a heating arrangement attached in order to control temperature. Air pressure was gradually introduced from below and the maximum pressure noted as the dough sheet began to expand. The volume of the bubble or thickness of film at the point of rupture was also determined. Chopin (1927) used a recording pressure gauge to measure the work required to extend a thin sheet of dough to the breaking point. Bailey and Le Vesconte (1924) used the Chopin Extensimeter to determine the effect of absorption, hydrogen-ion concentration, starch, and certain salts upon the extensimeter readings.

The Brabender Farinograph has proven very useful in controlling the consistency and temperature of doughs. Skovholt and Bailey (1932) have shown that variations in temperature markedly affect the farinograph readings and make it necessary to accurately control the temperature of the mixing bowl. Near and Sullivan (1935) have shown that the Farinograph can be used to predict the absorption of a flour dough. Some flours give doughs which slacken more during fermentation than other flours, so the Farinograph does not always give an accurate measure of the amount of water a bread dough should receive. Soft flours tend to feel stiffer than strong bread flours mixed to the same maximum farinograph value. However, weak flours tend to slacken more during fermentation, other factors being the same, than strong flours.

Markley (1935) has produced evidence to show that the width of the farinograph curve tends to be proportional to the height of the farinograph curve but does not indicate the elastic properties of the flour. Markley (1935) has also shown that the time required to reach a constant maximum farinograph value bears a significant positive correlation to the protein content. He also found that tight doughs reached a maximum farinograph value more quickly than slack doughs.

In the light of data to be presented in this article, the chief difficulties encountered in making comparative physical tests on flour doughs are the need for accurately controlling the mobility of the dough, the yield value, the type of dough mixer, time of mixing, percentage of salt in the dough as well as other ingredients, the need for accurate temperature control, and a uniform procedure for running the tests.



### Physical Nature of Dough System

Flour dough is an imperfectly elastic material exhibiting plastic properties to an appreciable degree. It is, therefore, of interest to consider some of the fundamental concepts of such systems.

According to Anderson (1919) solids possess rigidity or the ability to resist change in size or shape. The molecules which compose solids do not readily move with respect to each other. The strength of a solid is due to its intermolecular attraction or cohesion. The force of cohesion is exerted between like molecules, adhesion between unlike molecules.

*Elasticity.* When a force is applied to a solid body it always produces some change either in its length, its volume, or its shape. Elasticity is the tendency to resume the original condition upon removal of the applied force. When a metal bar is slightly stretched by a force, it resumes its original length upon removal of the force, by virtue of its tensile elasticity. If the bar is twisted, its recovery upon removal of the applied torque is due to its elasticity of torsion, rigidity, or shearing. A bar subjected to enormous hydrostatic pressure on all sides decreases in volume. On removal of pressure there is a tendency for the bar to immediately resume its original volume due to volume elasticity.

Ferry (1925) gives the following stress-strain diagram to represent an elastic solid:

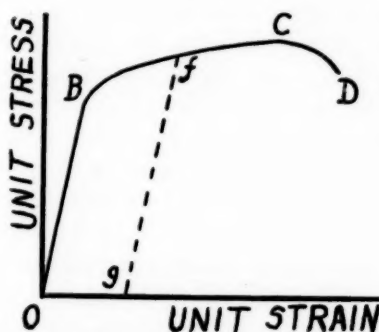


Fig. 1. (After Ferry (1925).) Diagram showing stress-strain relations for an elastic solid.

Unit stress = Force per unit area

Unit strain = Unit elongation per unit length

*B* = Elastic limit

*C* = Maximum stress

From *C* to *D* occurs the formation of the neck in ductile materials  
Rupture takes place at *D*

From *O* to *B* stress is proportional to strain and the solid is perfectly elastic between these limits. After the point *B* is reached, increases in stress cause a permanent deformation.

If the load at  $f$  be gradually diminished, the relation between unit stress and unit strain will be represented by the line  $fg$  nearly parallel to  $BO$ . When the load is completely removed there remains an increase in length  $Og$  called a permanent set.

Hookes' Law states that through wide ranges, most elastic substances are distorted in proportion to the applied or distorting force. For example, doubling the force produces twice as great stretch twist or shrinkage in volume as the case may be. A highly elastic body offers a great resistance to distortion and very nearly recovers its shape and size on the removal of the deforming force, *e.g.*, steel, glass.

A body is slightly elastic which is either deformed by a small force (gum rubber) or which can sustain but a small deforming force without permanent deformation (clay).

Dough is to be considered as being slightly elastic according to this definition with properties somewhere intermediate between rubber and clay.

When a body is perfectly elastic, a deforming force will develop in it an equal and opposite force of restitution which will not diminish with the lapse of time. A body which does not recover its original shape or size on the removal of the deforming force is said to be *plastic*. A body which can be deformed through wide limits without being permanently distorted is said to be *tough*. Certain high protein flour doughs are said to be tough or bucky. A body that can be distorted to but a very little amount without breaking is said to be brittle. The term "short" is used to describe this type of break in the case of flour doughs and baked products. Thus gum rubber is very tough though it is not highly elastic. Glass, on the other hand, is slightly tough but is very elastic; that is, glass cannot be distorted through a great range, but a distortion of glass develops a great force of restitution. Flour doughs appear to be imperfectly elastic according to Rejtö (1907) and small stresses appear to give permanent strains.

Figure 2 shows a stress-strain curve for a metal such as soft annealed copper, in which case the smallest loading produces a permanent elongation. At  $A$  the load was gradually removed and line 2 was obtained. On gradually increasing the load again line 3 was obtained.

In the case of perfectly elastic materials lines 1, 2, and 3 practically coincide. The deformations of crystalline minerals (quartz) and also the initial deformations of certain metals composed of crystal aggregates, below certain limiting loads, approximate the ideal of a perfectly elastic body (*e.g.*, wrought iron bar).

According to the data of Rejtö, flour doughs appear to give somewhat similar curves to Figure 2, although the stresses necessary to produce unit strain are very much smaller. Flour doughs also show

hysteresis effects somewhat similar to those shown by curves 2 and 3, Figure 2, according to Schofield and Scott-Blair (1933).

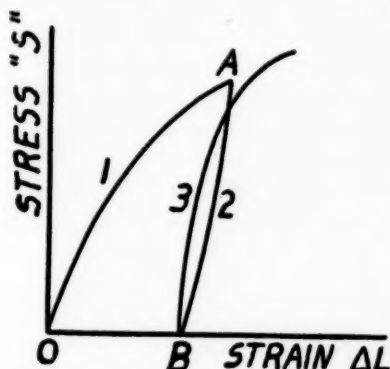


Fig. 2. (After Nadai (1931).) Stress-strain curve for metal such as soft annealed copper in which case the smallest loading produces a permanent elongation.

*Viscosity and fluidity.* According to Maxwell the viscosity of a substance is measured by the tangential force on a unit area of either of two horizontal planes at a unit distance apart required to move one plane with unit velocity in reference to the other plane, the space between being filled with the viscous substance. The coefficient of fluidity is equal to the reciprocal of the coefficient of viscosity.

$$\phi = \frac{1}{\eta} \quad \text{where } \eta = \text{coefficient of viscosity,}$$

$$\text{and } \phi = \text{coefficient of fluidity.}$$

Consider two parallel planes *A* and *B* separated by a distance *S*. If a shearing force *F* per unit area give the plane *A* a velocity *v* with reference to *B*, the velocity of each stratum between *A* and *B*, as pointed out by Newton, will be proportional to its distance from *B*. The rate of shear  $dv/ds$  is therefore constant throughout a homogeneous fluid under the above conditions assuming the absence of a boundary surface. The force *F* necessary to maintain a uniform velocity is opposed by the internal friction of the liquid. The coefficient of viscosity ( $\eta$ ) is equal to the ratio of the force *F* to the rate of shear.

$$\eta = \frac{Fs}{v},$$

$$\text{the coefficient of fluidity} \quad \phi = \frac{1}{\eta}$$

and

$$dv = \phi F dr. \quad (1)$$

*Plastic solids and mobility.* Bingham (1922) states that if an imperfectly elastic solid is subjected to a shearing stress, a part of the deformation remains long after the stress is removed. In plastic flow it is generally understood that a definite shearing force is required before any deformation takes place, but whether this is strictly true or not has not been established. Assuming a definite force ( $f$ ) is required, the excess  $F - f$  will be used in producing plastic flow thus:

$$dv = \mu(F - f)dr, \quad (2)$$

where  $\mu$  is the coefficient of mobility according to Bingham.

English and European workers usually speak of viscosity and fluidity in the case of plastic systems whereas Bingham would use the terms plasticity and mobility. Bingham's nomenclature will be used in this article.

Figure 3 gives a diagrammatic picture of viscous and plastic flow.

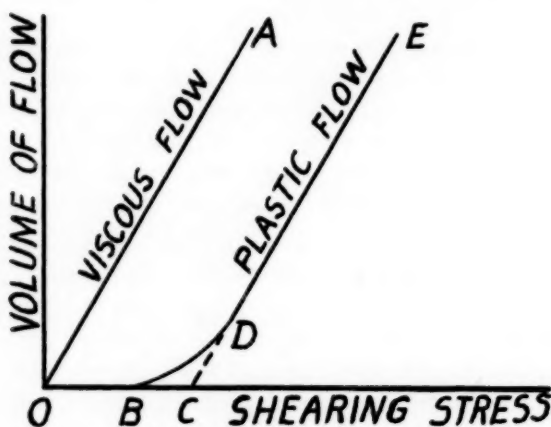


Fig. 3. Showing diagrammatically the relation between viscous and plastic flow.

In the case of viscous systems small shearing stresses produce flow and thus the line  $OA$  representing viscous flow starts from the origin, the slope of the line depending upon the viscosity of the system.

Plastic systems are represented as having a yield value  $OC$ . A certain amount of flow takes place before the shearing stress  $C$  is reached as shown by the curve  $BD$ . The yield point  $C$  is obtained by drawing a line through points on the curve  $DE$  and extrapolating. After the yield value is exceeded plastic flow takes place as represented by the line  $CE$ . Thus,

Plasticity = A yield value factor and a  $\frac{1}{\text{Mobility } (\mu)}$  factor.

This is not a mathematical relationship and thus the term plasticity

is very indefinite. The yield value factor is influenced by the elastic properties of the plastic solid. Mobility can be represented mathematically as shown in equation 2.

Schofield and Scott-Blair (1932, 1932a, 1933) studied some of the plastic properties of dough and investigated the appreciable elastic properties which go to make up the yield value. They applied a formulation based on Maxwell's "time of relaxation," which states that in the case of a fluid the relaxation is exponential, the rate of dissipation of internal stress is proportional to the stress, the constant of proportionality being the reciprocal of the relaxation time.

$$-\frac{ds}{dt} = \frac{1}{t_r} S,$$

$$\frac{1}{t_r} = -\frac{1}{S} \frac{ds}{dt} = -\frac{d(\log_e S)}{dt},$$

where

$T$  = time,

$S$  = shearing stress,

and

$t_r$  = relaxation time.

In the case of plastic solids the relaxation time is not a constant but varies according to the stress. The more purely elastic the material the longer the relaxation time. According to Maxwell's theory, in steady flow the velocity gradient (or rate of change of shearing strain),  $G$ , is related to the rate of dissipation of internal stress by the rigidity modulus,  $n$ , of the material. Thus,

$$-\frac{ds}{dt} = nG$$

so that the viscosity,  $\eta$ , which is defined as the ratio of  $S$  to  $G$ , is given by

$$\eta = nt_r.$$

Hence

$$t_r = \eta/n.$$

It was also shown that  $\eta = \frac{1}{3} Y t_r$  where  $Y$  is Young's modulus.

In the case of plastic materials,  $\eta$ , if defined as the ratio of  $S$  to  $G$ , is not a constant, but varies with  $S$ ;  $n$  on the other hand appears to be the constant of the material. Under low stresses the value of  $\eta$  for flour dough is considerable, while the rigidity modulus is extremely small by comparison with that of ordinary solids.

The doughs used in the experiments of Schofield and Scott-Blair were made up to about the same consistency by adding enough water



to the dough that it will just not stick to a glass plate when firmly pressed on its surface. All doughs were made up with 2.5% salt solution.

In one series of experiments cylindrical pieces of dough were subjected to tensile stresses for different lengths of time and the elastic contraction noted. Long cylindrical pieces of dough (made by forcing the material through a short piece of metal tubing attached to the body of a grease gun) were stretched out to different lengths and held stretched for a measured time and their elastic recovery noted.

In one experiment the weight of the dough was supported on a pool of mercury contained in a long narrow wooden trough. One end of the dough was fixed by pressing it round a screw let into one end of the trough while the other was attached to a thin strand of rubber by the extension of which the stress on the dough could be observed. The other end of the rubber strand was secured to a thread which could be wound up on a small winch. Direct observations on the decay of the stress were made by first rapidly extending the dough by winding the thread on the winch until after an extension of 150% (in some cases 50%) an ink mark on the dough came into the field of view of a low power microscope. The thread was then gradually released at a rate carefully regulated so as to keep the ink mark on the cross hair of the microscope. From a separate calibration the stress corresponding to each notch was known and this, divided by the mean cross section, gave the stress in dynes per square millimeter.

Schofield and Scott-Blair in their discussion of dough structure state that dough contains elastic elements which form a connected structure and that the determination of Young's modulus has reference to these elements. These elastic elements, though connected, are not joined securely but slide past each other when a sufficient stress is operative and thus effect viscosity. The elastic elements may be capable of elastic recovery but there is no criterion for testing this.

A considerable time often elapses between the release of stress and the cessation of contraction and this indicates a second type of viscosity which may be associated with the medium in which the elastic elements are embedded. It may also be somehow connected with the elastic elements and their system of connection.

The elastic elements are identified with the protein part of the flour, which forms a continuous structure as evidenced by the fact that the starch and other constituents of the flour can be washed out of the dough without breaking up the gluten. The slowness of elastic recovery is partly, at least, due to hydrated starch in the dough since the elastic recovery for washed gluten is more rapid. The elastic recovery of washed gluten is not instantaneous so that a part of the second viscosity is attributable to the gluten.

It will be noted that Schofield and Scott-Blair do not use the nomenclature of Bingham since they speak of viscous flow in the case of plastic solids where Bingham would speak of plastic flow. Moreover Schofield and Scott-Blair appear to separate the elastic properties of dough from the plastic properties whereas Bingham would consider elasticity as entering into the yield value of a plastic solid. However, the meaning is clear and differences in nomenclature should not lend any confusion to their interesting picture of the mechanical structure of flour dough.

### Experimental Apparatus Used

Schofield and Scott-Blair (1932, 1932a, and 1933) devised an apparatus whereby a cylindrical piece of dough could be stretched for varying lengths of time and the dying out of stress noted, as well as the elastic properties remaining in the dough. They used an elastic gum rubber band to measure the stresses. Each rubber band was standardized so that the stresses created were known by the increase in its length.

The dough gun and mercury bath used in the experiments to be described in this article were similar to those devised by Schofield and Scott-Blair. A so-called "stress balance" was used instead of an elastic band to measure stresses imposed upon the dough cylinder.

Figure 4 gives a general idea of the apparatus used in making stress measurements. The dough stretching mechanism consisted of

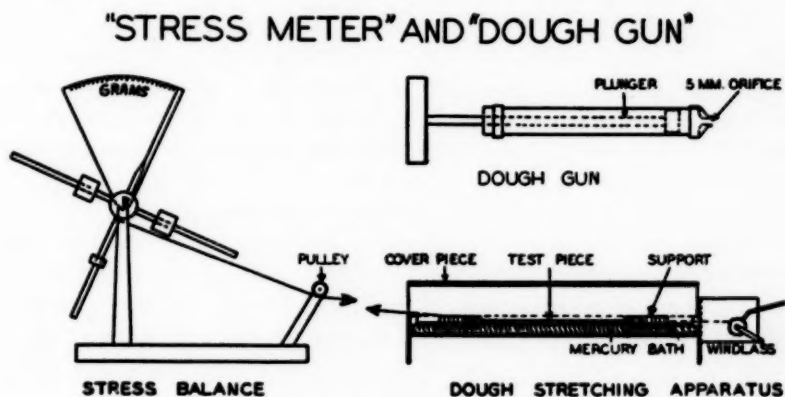


Fig. 4. Apparatus used for measuring stress-strain relations in flour dough.

a hemi-circular iron bath about 25 cm. long and about 3 cm. in diameter (inside measurements). A windlass was attached to one end with a ratchet mechanism for holding the windlass in position, when under stress. The test piece of dough was suspended on a mercury bath between two supports as shown. Considerable difficulty was experi-

enced in getting supports which would hold the dough under fairly large stresses without tearing the dough. A simple device was at last found which performed its purpose very well, and even when a dough was stretched to its breaking point it broke in the centre and did not break at the supports. This consisted of a tongue and grooved piece of wood made from 22 mm. lumber and with the tongue cut narrower. The end of the cylindrical piece of dough was placed in the groove and the tongue firmly pressed down upon it so as to wedge it in. One support was attached by a stout thread to the windlass while the other end was attached by a thread to the lower beam of the tension balance. The thread was attached close to an imaginary line drawn between the knife edges, so that changes in the scale reading would affect the length of the stretched dough the smallest possible amount consistent with a fairly wide and sensitive scale reading on the stress balance.

The dough stretching apparatus had a metal cover over the mercury bath with a glass top and blotting paper fitted into slots in the sides. This blotting paper was kept moist during the tests. There were holes in the stretching mechanism to allow the threads to pass through. Such a cover works efficiently in preventing the dough from drying or scaling during the test. If the surface of the dough dries out, the results will be vitiated. The cover was supported by flanges whereby it could be removed readily.

The stress balance was supported by a burette stand with two V-shaped supporting columns into which the knife edges of the balance fitted. The balance proper had three threaded adjustment arms with weights and a pointer as shown in Figure 4. Such an arrangement made it possible to vary the sensitivity of the balance at will by adjusting the relative positions of the three weights on the adjustment arms.

In graduating the scale for the stress balance, the position of the pulley was lowered so as to keep the position of the string between the balance and pulley the same. Gram weights were hung on the end of the string and the scale of the balance was suitably graduated in grams. Such a stress balance arrangement gave sufficiently reliable results for the tests to be described and the construction was sturdy and dependable.

Figure 4 shows the dough-gun used to obtain the cylindrical test pieces of dough. It was made of bronze throughout with the exception of the handle of the plunger which was made of wood. The diameter of the cylinder was 22 mm. (inside dimensions) and the length 17 cm. There were screw caps on both ends of the cylinder to facilitate placing the dough in the gun and for ease in cleaning. The plunger passed

through one cap, whereas there was an orifice in the other end 5 mm. in diameter and 7 mm. long, through which the dough was forced to form a dough cylinder.

The dough was placed in the gun by carefully and smoothly rolling a round piece of dough into a cylinder just small enough to pass into its barrel. Preliminary tests indicated that it was advisable to take a portion of the dough out of the mixer immediately after mixing, roll it out into a cylinder, place it in the gun and later squeeze out a small amount of dough. Readings on the stress meter on a test piece of dough tended to be low and erratic unless the dough had rested at least seven minutes after placing it in the gun. This gives time for the stresses in the dough to die out. It usually took about three minutes to place the dough in the gun after which the dough stood seven minutes. A reading was then taken on the stress meter and this reading was called the ten minute reading.

Stress readings were taken as follows: The supports, riding freely on the mercury bath, were placed about 1.6 to 2 cm. apart, and about 5 cm. of dough forced out of the gun. Thus  $1\frac{1}{2}$  cm. of dough approximately rested in the grooves of each support. The tongues of the supports were then pressed down upon the dough into the grooves. The ends of the tongue and groove were maintained flush, since the distance between the supports was taken to be the length of the test piece. This distance was measured to the nearest half millimeter with a celluloid ruler graduated in millimeters. As already stated the usual length of the test piece was 1.6 to 2.0 cm.

Schofield and Scott-Blair had shown that the time of relaxation was dependent upon the stress to which the dough was subjected. They used a 50% and a 150% extension of their doughs in one series of experiments. Since a dough in the ordinary process of fermentation expands at least five times its original size, it was decided arbitrarily to stretch the dough to five times its original length, hold it at this length and watch the manner in which the stress died out with time. One is thus observing a so-called plastic flow in the test piece. Thus, if the original length of the test piece of dough was 1.85 cm., the dough would be stretched to a length of  $5 \times 1.85$  or 9.25 cm. The stretching was carried out as evenly as possible by means of the windlass and the stretching time held constant at ten seconds in all experiments reported here. The first reading on the stress balance was taken after an additional five seconds. This reading was called the 15 second (10 + 5) reading on the test piece. Additional readings were recorded on the stress balance at the end of 30 seconds, 1 minute, and 2 minutes. The test piece of dough was then removed. At the end of 15 minutes after mixing the dough, a second test was commenced

(i.e., after the dough had rested in the gun for approximately 12 minutes), and a duplicate set of readings were taken on the stress balance. A third test was then run on the dough at the end of 20 minutes from the time of mixing.

*Accuracy of results.* These triplicate sets of readings taken 10, 15, and 20 minutes after mixing (approximately 7, 12, and 17 minutes after placing in the dough gun) were found to give fairly consistent readings. The first set of readings tended to be slightly higher than the second set, whereas the third set of readings were slightly higher than the first but lower than the second. The arithmetic mean values on the 15 seconds stress meter readings for 90 tests were as follows.

TABLE I  
AVERAGE STRESS RESULTS FOR 90 TESTS

Period of rest, <i>Minutes</i>	10	15	20
Average reading, <i>Grams</i> (15 second readings)	17.00	17.96	17.39

In order to estimate the discrepancies to be expected between the 10, 15, and 20 minute rest periods for individual flour doughs, the differences between the 15 second reading on the 10 minute and the 15 minute rest periods, and the 15 minute and the 20 minute rest periods were obtained in each of 90 flour doughs and the arithmetic means computed. The mean difference between the 10 minute and the 15 minute rest periods was 1.67 grams and the mean difference between the 15 minute and 20 minute rest periods was 1.26 grams. Thus, readings such as the following might be expected by the method used.

TABLE II  
REPRODUCIBILITY OF RESULTS

Period of rest, <i>Minutes</i>	10	15	20	Average
15 second stress reading, <i>Grams</i> or	17.0 18.7	18.7 17.0	17.4 17.4	17.7 17.7

As shown in Table I, however, the 10 minute rest period usually gave the lowest reading, the 15 minute rest period the highest reading, and the 20 minute rest period an intermediate value.

The 10, 15, and 20 minute rest period tests were averaged for the 15 second, 30 second, 1 minute, and 2 minute readings, as shown in Table II for a 15 second reading.

Nearly all tests were made in duplicate on different days. Thus, a second average value as shown in Table II was obtained on some



succeeding day. In order to determine the accuracy of such duplicate tests 36 samples of flour doughs in duplicate were submitted to statistical analysis. The average stress-meter reading on all samples was 17.6 grams. The average difference between duplicate tests run on different days was 0.77 grams; 78% of the readings had a mean difference of 1.0 gram or less.

In order to further study the accuracy of the results obtained, 12 separate tests on a sample of medium strength flour were subjected to analysis. A standard deviation of 0.45 was obtained for the 15 second reading (each reading reported represents an average of 3 stress readings).

Nearly all tests reported in this paper were duplicated on different days. Moreover, three separate stress meter readings were taken on each dough mixed, so that results reported in this paper are the average of six stress readings unless otherwise stated. This considerably eliminates inaccuracies that would otherwise result from single stress readings.

It was found that duplicate tests run on the same day showed better agreement than checks run on different days. When comparing about 4 samples of flour, therefore, the comparisons were made on one day and a check series was run on a later day. The reason for this was clearly brought out by results to be reported. Variations in temperature of mixing, and conducting the stress test cause marked variations in the results. Humidity may also very slightly affect the results, although the dough was left exposed to the air for a minimum time in all cases. An endeavour was made to hold the temperature of the room as constant as possible. It would be advisable to have a thermostatically controlled room and a humidity control.

*Dough mixer.* The official Hobart-Swanson mixer of the A. A. C. C. was first used to mix flour doughs for testing with the stress meter. It was soon found, however, that the stress readings varied so largely with changes in temperature and in the absorption or consistency of the dough, that it was necessary to mix all doughs on the Brabender Farinograph to a constant maximum value of 540 farinograph units. By this means the consistency of the dough could be kept constant as judged by the baker.

Flour doughs were first made up with the following formula.

DOUGH FORMULA 1

Flour.....	300 grams
Water.....	Sufficient water to give a consistency of 540 farinograph units
Salt.....	2%

Salt has been shown by Skovholt and Bailey (1932) to have a very marked effect on the nature of the farinograph curve and it was

decided to include this ingredient in the formula. Later in this investigation, it was found that it was advisable to use a baking formula as shown in formula 2. A dough made from formula 2 takes about a 50% longer time to develop to a maximum peak on the farinograph curve than a dough made by formula 1.

## DOUGH FORMULA 2

Flour.....	300 grams
Water.....	Sufficient to give a consistency of 540 farinograph units
Yeast.....	3%
Salt.....	2%
Sugar.....	3½%
Shortening.....	2%

Diastatic malt extract and powdered milk solids, not fat, were also found to appreciably affect the results and although these are frequently used in commercial baking it was thought advisable to study these factors separately. All results reported in this article were taken on doughs mixed according to formula 2 unless otherwise stated.

*Temperature.* Assuming a constant absorption, temperature of dough has a marked effect on both the farinograph and the stress meter readings. It is therefore necessary to carefully control the temperature. In the case of the stress meter the temperature of the room and instrument was kept as closely as possible to the desired temperature of the dough.

It is common bakery practice in the United States and Canada to mix straight doughs to a temperature around 78 to 80° F. Sponge doughs are commonly mixed to 72 to 76° F. Since formula 2 is that of a straight dough it was decided to run all stress meter readings and farinograph mixings at a temperature of 26° C. or 78.8° F.

*Flour samples.* Three samples of flour were used throughout the investigation. These consisted of a strong baker's flour made from Northwestern spring wheat, a medium strength family patent flour made from a blend of Northwestern and Kansas wheat, and a high grade cake flour matured with chlorine to a pH = 5.2 when the flour was suitably suspended in water. The analysis of these samples of flour were as follows:

TABLE III  
CHEMICAL ANALYSIS OF FLOUR SAMPLES USED<sup>1</sup>

Sample number	Flour used	Crude protein (N×5.7)	Ash	Moisture	Diastatic activity
		%	%	%	Blish units
16326	Strong flour	13.2	0.51	10.6	214
16327	Medium strength	11.8	.39	9.3	225
16328	Cake flour	8.1	.33	10.6	91

<sup>1</sup> Uncorrected for moisture.

These samples were used throughout the investigation with the exception of a variety series study.

*Fermentation.* In many of the experiments reported in this article stress meter readings of the dough were made directly after mixing, and the dough was then allowed to ferment for 3 hours at a temperature of 26° C., placed in the Farinograph and mixed for five minutes after which the standard technique was again used to obtain stress meter readings. It is realized that the mixing in the Farinograph at the end of 3 hours fermentation may alter the properties of the fermented flour dough. This was the only manner however in which the gas could be worked out of the dough and concordant results then secured with the stress-meter.

*Correction for diameter of test piece.* It was soon observed that the diameter of the test piece of dough pressed from the dough-gun varied from about 1 to 1.3 cm. Strong flours seemed to give the large diameters and weak flours the small diameters. The rate at which the dough was forced through the orifice of the dough-gun also influenced the diameter of the test piece. It is debatable, however, as to whether or not the test piece should be corrected for area. The test piece has been emitted from the same orifice at the same approximate speed and pressure. Moreover, it would appear that the more elastic the dough the larger the diameter of the dough, assuming the dough has been mixed to the same consistency on the Farinograph. Unless otherwise stated stress readings given in grams are uncorrected for area, this value being considered more significant than the corrected value.

## RESULTS

*Decay of stress with time.* Schofield and Scott-Blair have shown that the time of relaxation varied with the per cent elongation of the original test piece of dough. A 150% extension of the test piece of dough gave higher stress values and a longer time of relaxation than a 50% extension.

From the results reported in Table IV and in Figures 5 and 6 using a 500% extension it will be noted that the strength of the flour has an effect upon the time of relaxation as well as the magnitude of the stress readings.

The stress readings fell off very rapidly at first and then more gradually as the time increased. The dough was undergoing a type of plastic or mobile flow. Stresses continue to die out of the gluten structure work of the flour dough until theoretically the yield value is reached, when plastic flow ceases.

TABLE IV  
EFFECT OF TIME OF STRETCHING DOUGH ON THE STRESSES EXHIBITED BY STRONG,  
MEDIUM STRENGTH AND CAKE FLOURS

Time under stress	Log. time	Strong flour		Medium strength flour		Cake flour	
		Stress	Log. stress	Stress	Log. stress	Stress	Log. stress
<i>Minutes</i>		<i>Grams</i>		<i>Grams</i>		<i>Grams</i>	
0.25	1.3979	25.3	1.4605	20.0	1.3010	12.4	1.0934
0.50	1.6989	18.5	1.2672	15.5	1.1903	9.3	0.969
1	0.0000	15.6	1.1931	13.2	1.1206	7.7	0.887
2	0.3010	11.8	1.0719	11.0	1.0414	6.4	0.806
3	0.4771	11.0	1.0414	—	—	—	—
4	0.6020	10.2	1.0086	9.1	0.959	—	—
5	0.6989	9.0	.9542	—	—	5.1	0.708
10	1.0000	8.4	.9243	7.1	0.851	4.1	0.613
15	1.1760	7.2	.8573	6.1	0.785	3.9	0.591
20	1.30100	6.4	.8062	5.6	0.748	3.7	0.568
25	1.39394	6.0	.7782	5.2	0.716	3.3	0.519
30	1.47712	5.4	.7324	4.8	0.681	3.1	0.491

In Figure 6 the logarithm of the stress is plotted against the logarithm of the time. Approximately straight lines are obtained and the three different strengths of flours give lines which are about parallel to each other.

One of the interesting features of these curves is, that in spite of the fact that the maximum farinograph readings are the same for the

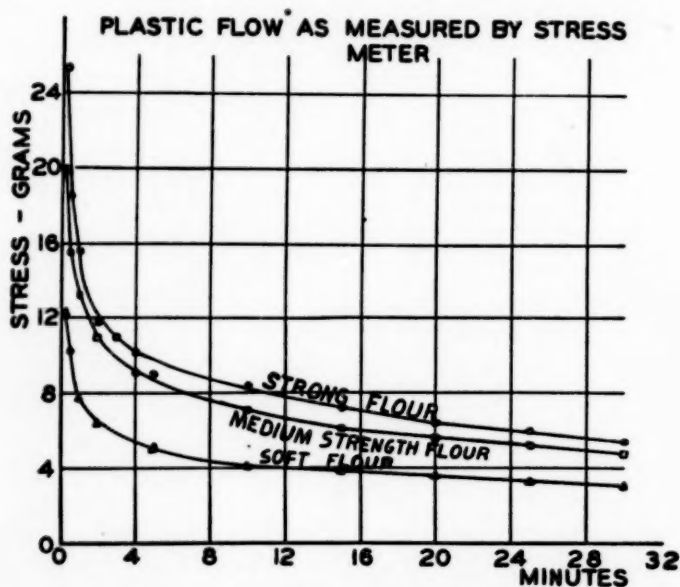


Fig. 5. Stress-strain relations for strong, medium strength and weak flours.

three different strengths of flour doughs, the stress meter readings are different.

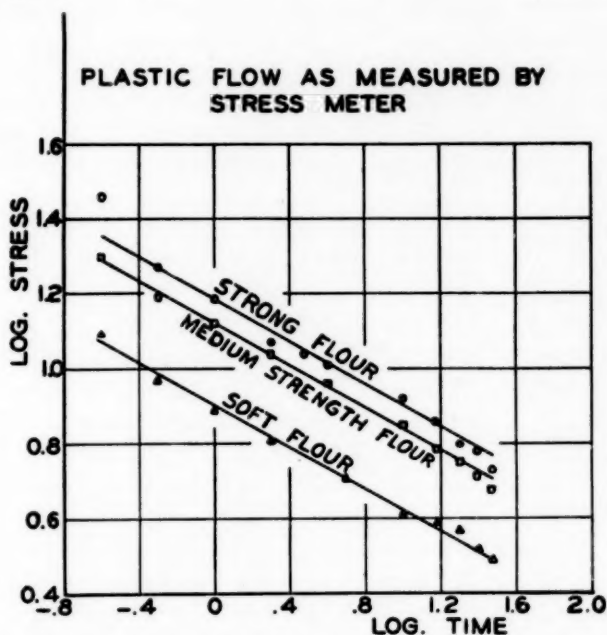


Fig. 6. Logarithmic chart of stress-strain relations for strong, medium strength and weak flours.

### Variety Studies

The Northwest Section of the A. A. C. C. carried out a collaborative study to compare certain varieties of wheats and the effect of growing these varieties at different stations. These varieties included samples of Marquis, Ceres, Reward, and Thatcher wheat grown at Leeds, Fargo, and Tioga, North Dakota; Ft. Benton and Glasgow, Montana (No. 1 and 2); and Crookston, Minnesota. They were commercially milled on a 50 barrel mill.

A series of Kansas flours was also obtained as well as four samples of Minnesota flours. All flours were of the 1934 crop.

Table V gives some of the results obtained with these samples. These data include stress readings, protein content of flour, loaf volumes for 2- and 5-minute mixing times on the Hobart-Swanson mixer and baking quality scores for the 2- and 5-minute mixing times. The baking quality score was calculated as follows:

$$\text{BAKING QUALITY SCORE} = .1 (\text{Loaf volume in cc.} - 200) \\ + 2 (\text{Grain score} - 90) + (\text{Texture score} - 90) + \text{Loaf Type Score}$$

The baking data were taken from the reports of M. C. Markley.



TABLE V  
VARIETY STUDIES

Sample number	A	B	C	D	E	F	G
	Stress	Crude	Loaf	Volume	Baking	Quality	Stress
	(15-second reading)	protein (N×5.7)	2-min-ute mix	5-min-ute mix	2-min-ute mix	5-min-ute mix	(15-second reading) 3 hours fermentation
	Grams	%	Cc.	Cc.	Score		Grams
Northwest Section A. A. C. C., Varieties Studies 1935							
<i>Marquis</i>							
2949	20.3	15.26	665	672	77.0	76.2	11.1
2932	19.2	16.48	852	582	99.7	62.2	8.9
2947	21.7	14.74	737	622	82.7	66.2	10.7
2944	14.2	14.38	617	442	57.2	25.7	6.9
2924	21.5	12.73	565	557	65.0	67.7	10.6
2948	20.3	15.34	705	612	82.5	69.7	10.1
2950	21.2	15.30	707	662	83.2	75.5	11.5
<i>Ceres</i>							
2978	19.7	14.92	675	685	79.0	76.0	6.2
2933	19.4	16.20	810	600	92.0	57.5	8.8
2952	22.7	14.93	660	665	76.5	76.5	8.4
2980	12.0	15.24	650	465	65.0	28.5	9.5
2925	21.2	12.84	585	560	73.0	68.0	9.2
2965	20.0	15.86	802	580	91.7	61.0	9.6
2951	20.5	14.86	627	632	74.2	72.2	10.2
<i>Reward</i>							
2946	18.0	16.03	905	600	102.5	66.0	11.3
2934	18.3	16.01	847	607	98.2	58.7	6.5
2935	20.9	15.50	777	655	90.7	74.5	8.0
2945	10.2	14.98	602	455	53.7	26.5	5.1
<i>Thatcher</i>							
2962	24.0	15.42	697	707	79.7	77.7	11.3
2936	21.3	17.17	1020	655	113.5	69.5	13.0
2972	21.3	15.36	785	665	90.0	70.5	9.9
2979	13.3	15.00	620	445	64.0	26.5	8.8
2928	19.3	13.73	695	555	80.0	65.5	9.8
2964	22.0	16.02	705	720	86.0	81.5	13.0
<i>Kansas flours</i>							
15883	15.1	10.90	615	475	66.5	45.5	
15882	16.7	12.80	665	500	70.5	44.0	
15884	15.5	11.50	605	505	70.5	48.5	
15885	16.3	10.40	635	535	70.5	52.5	
15918	16.2	12.20	595	520	65.5	50.0	
15919	16.0	13.90	700	545	75.0	53.5	
15921	14.5	14.40	660	555	60.0	49.5	
15924	18.0	10.10	560	490	86.0	58.0	
<i>Minnesota flours</i>							
Ceres	19.9	11.30	510	490	61.0	49.0	
Hope	19.0	11.80	515	585	60.5	47.5	
Marquis	17.2	10.10	470	465	56.0	49.5	
Thatcher	16.9	11.80	500	485	60.0	42.5	
Arith. mean	18.43	14.04	676.7	570.8	76.64	58.05	
Coefficient of correlation (r)			AB	AC	AD	AE	AF
			.27	.29	.79	.54	.90
Coefficient of correlation (r)					BD	BE	BF
					.35	.57	.62

The protein content of this series of flours is unusually high throughout, even though there is considerable variation in the loaf volume, baking quality scores, and stress readings.

Samples No. 2944, 2980, 2945, and 2979 all came from Fort Benton. Although they are high in protein content, the flours exhibited decided weaknesses in handling and in tolerance to prolonged mixing. Their stress readings class them with soft cake flours, and yet their loaf volumes on a 2-minute mix are only slightly below the average for the series.

The coefficients of correlation of the stress readings with protein content, loaf volumes, and baking quality scores were computed for the 36 samples (Table I). The 5% point for the coefficient of correlation is  $r = .33$  (the value of  $r$  where you have one chance in twenty of getting this value by chance).

No significant correlation ( $r = .27$ ) was found between the stress value readings in grams (uncorrected for area) and the protein content. If enough samples were included a significant positive correlation might be obtained even though the correlation was not high. The stress value did not vary directly with protein content, however, and the former apparently included some of the dough strength characteristics which are not due solely to the quantity of protein.

The stress reading was then compared with the loaf volume of doughs mixed for two minutes, and no significant ( $r = 0.29$ ) correlation was obtained. This was a little surprising as one might have expected a positive correlation between these two values. However, a small positive correlation between the stress value and the baking quality score for the 2-minute mix ( $r = .54$ ) indicated that there was some correlation between the stress value and the quality of bread.

A 2-minute mixing time on a Hobart-Swanson Mixer will develop nearly all the flours shown in Table V to the optimum degree. It is possible that the high protein flours would require around three minutes mix to reach a stage where they would be spoken of as being "dry" by the baker or their optimum stage of development. In order to see how the flours would withstand prolonged mixing Dr. Markley subjected the flour doughs to a 5-minute mixing period with the Hobart-Swanson Mixer and then baked them. Under these conditions some doughs break down more than others and the baking results shown with a 5-minute mix are frequently quite different from those resulting from a 2-minute mix.

A significant correlation ( $r = .79$ ) was obtained between the stress value and the loaf volume with a 5-minute mixing time. Moreover, a high correlation ( $r = .90$ ) was obtained between the stress value and the baking quality score with a 5-minute mixing time. This would

indicate that the stress value as measured with the stress meter, directly after mixing the dough, tends to measure the ability of a dough to withstand excessive mixing and severe physical treatment in the bake shop.

The stress readings at the end of 3 hours fermentation of the dough were also taken. No correlation with the previous data is evident from scanning these readings. It is to be noted, however, that there is a decided reduction in the stress readings during fermentation which suggests that progressive fermentation does not "develop" dough but rather "mellows" it to a physical condition that is conducive to the formation of thin dough films that will be extended sufficiently in the baking process to yield bread of superior texture.

Coefficients of correlation of protein content with loaf volumes, and baking quality scores were also computed (see Table V). A slight correlation ( $r = .35$ ) of the protein content with loaf volume of the 2-minute mix, and a correlation of  $r = .62$  with the baking quality score of the 2-minute mix was thus determined. These correlations are somewhat higher than those obtained between 15-second stress readings and the loaf volume score and baking quality score of doughs mixed for 2-minutes. However, the correlation of protein content with loaf volume ( $r = .57$ ) and the baking quality score ( $r = .35$ ) for doughs mixed for 5 minutes is much lower than the correlation of stress value reading with loaf volume ( $r = .79$ ) and the baking quality score ( $r = .90$ ) of these doughs. This agrees with what has previously been stated, that the protein content does not necessarily disclose the ability of a dough to withstand prolonged mixing abuse, even though it may be a good indication. Stress readings appear to give a more accurate indication in this regard. On the other hand, protein content seems to be a better indication of the baking quality of a dough which is not subjected to severe treatment.

In discussing flour strength the ability to withstand severe conditions, such as overmixing, severe machine handling of the dough in the bake shop; the ability of a flour to carry large proportions of low strength flours, and possibly oxidizing agents and enzyme mixtures may need to be included.

### Summary

Bread dough is a plastic solid which has imperfectly elastic properties. Plastic solids are usually thought of as possessing a yield point where plastic flow commences, and after which the volume of flow is proportional to the force exerted. The yield point is influenced by the elastic properties of the plastic material.

A stress meter has been described which can be used to study the stress-strain relations of flour doughs, including a study of plastic

flow by measuring the dying out of stress with time of stretching the dough.

Strong flours give higher stress readings than weak flours when stretched to five times their original length and given various relaxation times.

Wheat variety studies showed that high stress meter readings are a good indication of the ability of a dough to withstand prolonged mixing, as shown by baking tests.

#### Literature Cited

- Anderson, W. B.  
1919 *Physics for Technical Students*. McGraw-Hill Book Company.
- Bailey, C. H.  
1925 *The Chemistry of Wheat Flour*. Chemical Catalogue Company, New York.
- and LeVesconte, A. M.  
1924 Physical tests of flour quality with the Chopin extensimeter. *Cereal Chem.* 1: 38-63.
- Bayfield, E. G.  
1935 The effect of some factors influencing viscosity and protein. *Cereal Chem.* 12: 1-16.
- Bingham, E. C.  
1922 *Fluidity and Plasticity*. McGraw-Hill Book Company.
- Case, John  
1925 *Strength of Materials*. Published by Edward Arnold and Company.
- Chopin, Marcel  
1927 Determination of baking value of wheat by measure of specific energy of deformation of dough. *Cereal Chem.* 4: 1-13.
- Ferry, E. S.  
1925 *General Physics*. John Wiley & Sons, Inc., New York.
- Hankoczy, Eugen  
1907 *Der ungarische Weizen und das ungarische Mehl von Thomas Kosutany*. Druck der "Molnarok Lapja" Buchdruckerei.
- Kress, C. B.  
1924 Gluten quality. *Cereal Chem.* 1: 247-250.
- Markley, Max  
1935 Papers presented at Cereal Chemists Convention (1935) and to be published in *Cereal Chemistry*.
- Nadai, A.  
1931 *Plasticity*. McGraw-Hill Book Company.
- Near, Cleo, and Sullivan, B.  
1935 The use of the farinograph as an accurate measure of absorption. *Cereal Chem.* 12: 527-531.
- Rejtő  
1907 *Der ungarische Weizen und das ungarische Mehl, von Thomas Kosutany*. Druck der "Molnarok Lapja" Buchdruckerei, Budapest.
- Schofield, R. K., and Scott-Blair, G. W.  
1932 I. The relationship between viscosity, elasticity and plastic strength of soft materials as illustrated by some mechanical properties of flour doughs. *Proc. Roy. Soc., A* 138: 707-718.
- 1932a II. *Proc. Roy. Soc.* 139: 557-566.
- 1933 III. *Proc. Roy. Soc.* 141: 72-85.
- 1934 Apparatur zur Bestimmung der mechanischen Eigenschaften von Mehlteigen in absoluten Einheiten. *Das Mühlenlaboratorium*. Band 4, Heft 4: 42-46.
- Skovholt, Oscar, and Bailey, C. H.  
1932 The effect of temperature and of the inclusion of dry skim milk upon the properties of doughs as measured with the farinograph. *Cereal Chem.* 9: 523-530.

# STUDIES ON EXPERIMENTAL BAKING TESTS. III. THE EFFECT OF VARIOUS SALTS ON GAS-PRODUCTION <sup>1</sup>

R. K. LARMOUR <sup>2</sup> and H. N. BERGSTEINSSON <sup>3</sup>

Department of Chemistry, University of Saskatchewan, Saskatoon, Sask., Canada

(Read at the Annual Meeting, June, 1935)

## Introduction

Most of the studies on effect of salts on fermentation of wheat-flour doughs have dealt with either varying amounts of NaCl or some fixed amount plus smaller quantities of other salts such as  $\text{NH}_4\text{Cl}$ ,  $\text{NH}_4\text{H}_2\text{PO}_4$ ,  $\text{KBrO}_3$ , *etc.* The salts other than NaCl are usually added for their supplementary effect on either gluten properties or yeast. Any comprehensive study of the specific effect of these other salts is impossible with this procedure, because with the customary dosage of NaCl only small additional quantities of the others can be added without "over-salting" the dough and causing secondary effects which would obscure the results. If one were desirous of observing effects of specific salts, it would seem reasonable to replace the NaCl wholly by the salt to be studied and then, after determining the behaviour of the doughs with each salt, one could proceed to observe the effect with mixtures including NaCl.

The work herein reported followed this line of investigation. It was undertaken with the desire to ascertain the specific action of various salts in the hope of finding some means for prolonging the fermentation period. Although this was not realized, some very interesting data were obtained and they are herewith presented as a contribution to the work of the baking-test committee.

The salts used in this study were NaCl, KCl,  $\text{NH}_4\text{H}_2\text{PO}_4$ ,  $\text{NH}_4\text{Cl}$ ,  $(\text{NH}_4)_2\text{SO}_4$ ,  $\text{NaH}_2\text{PO}_4$ ,  $\text{Na}_2\text{HPO}_4$ ,  $\text{Na}_3\text{PO}_4$ ,  $\text{Na}_2\text{SO}_4$ , and  $\text{NaHSO}_4$ . These were used in the following concentrations: 0, 0.01, 0.02, 0.03, and 0.04 equivalents (based on the anion) per 100 g. of flour. The concentration 0.02 equivalents per 100 g. flour is 1.12% for NaCl. As this is close to the customary dosage, it was decided to use the above noted simple fractions of equivalents as a matter of convenience.

<sup>1</sup> Issued as paper No. 95 of the Associate Committee on Grain Research, National Research Council of Canada, with financial assistance from the Saskatchewan Agricultural Research Foundation and the National Research Council of Canada.

<sup>2</sup> Professor of Chemistry, University of Saskatchewan.

<sup>3</sup> Graduate Assistant, Associate Committee on Grain Research, University of Saskatchewan.



The procedures for preparing the doughs and measuring the  $\text{CO}_2$  production were the same as described by Larmour and Brockington (1934). The doughs were made up by the A.A.C.C. basic formula except for the salt, which was varied in kind and amount. The flour used throughout these experiments was a well-aged, unbleached, commercial patent having a diastatic activity (Ferricyanide method) of 226 Rumsey units. Measurements of  $\text{CO}_2$  produced were made at 10-minute intervals and the results recorded as cc. of  $\text{CO}_2$  produced per 10 minutes by a quarter-dough, representing 25 g. flour. In most cases observations were made over a period of five hours or longer. The data, on account of their bulk, have not been given in tabular form but are shown graphically as rate curves.

**NEUTRAL SALTS**— $\text{NaCl}$ ,  $\text{Na}_2\text{SO}_4$ . The effects of different concentrations of these salts on rate of  $\text{CO}_2$ -production in doughs are shown graphically in Figure 1. For comparison there is also included the rates for dough without any added salt.

The general character of the curves is similar for both salts. There is a sharp increase in rate of  $\text{CO}_2$ -production during the first 80 minutes, at about which time a maximum is reached; thereafter the rate decreases about as fast as it rose for 30–40 minutes. This is followed usually by a slight increase, after which there begins a slow decrease in rate with no subsequent tendency towards acceleration. The second acceleration of rate of  $\text{CO}_2$ -production which always occurs with the basic formula was observed by Brockington (1932), who thought at first that it was due to experimental error. Careful experiments, however, convinced him that it is characteristic of this formula and is associated with the rate of diastasis of starch. He observed, however, that the relative amounts of yeast and sugar were also important factors, noting particularly that with low yeast formulas the curves showed no sign of this second acceleration of rate. In view of Brockington's data and the observations recorded in this present investigation, there is little doubt that these irregularities in the rate curves are real and are not attributable to experimental error. The interpretation of them will be discussed later in this paper.

It should be noted that the doughs without salt tended to gas somewhat more slowly than the salted doughs during the first hour, but thereafter they gassed at a higher rate. Increase in concentration of salt in each case lowered the rate of gassing, but the difference with 0.01 and 0.02 equivalents was not great.

Comparing the two salts, the  $\text{Na}_2\text{SO}_4$  doughs did not attain as high a maximum as the  $\text{NaCl}$  doughs, but after two hours the rates for corresponding concentrations were nearly the same and during the period 180 to 235 minutes, which corresponds to the pan-proofing, they were practically identical.

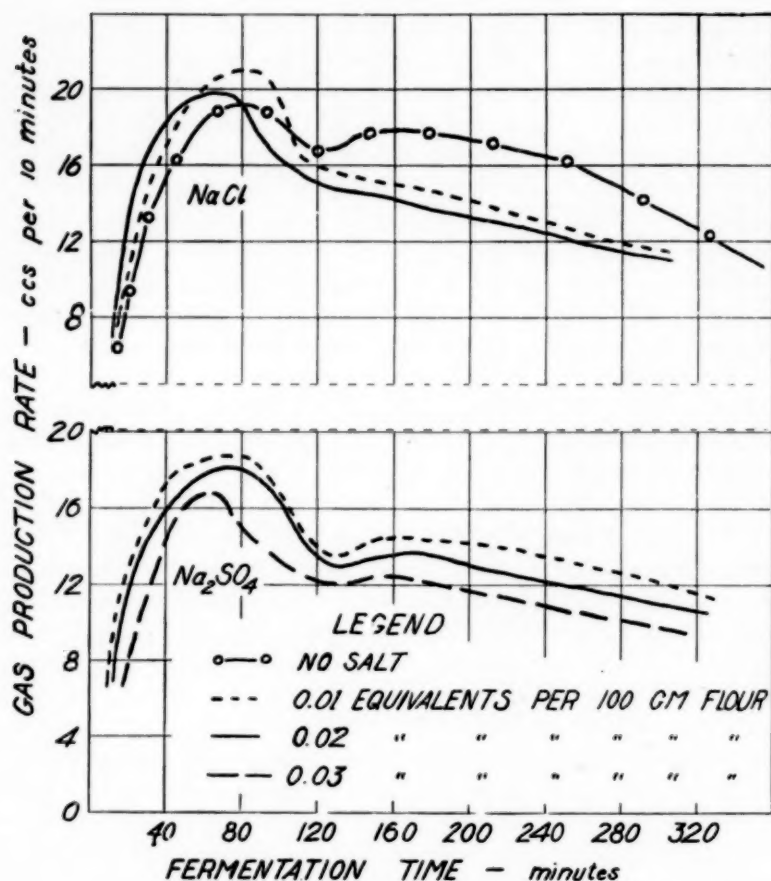


Figure 1. CO<sub>2</sub>-production rates with different concentrations of NaCl and Na<sub>2</sub>SO<sub>4</sub>.

**AMMONIUM SALTS**—(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>, NH<sub>4</sub>Cl, NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub>. The curves in Figure 2 show the very remarkable similarity of the three ammonium salts (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>, NH<sub>4</sub>Cl, and NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub>. In all cases the CO<sub>2</sub> production rate rises during the first 80 minutes to a maximum of approximately 20, then decreases to a minimum at about 120 minutes, and thereafter rises again quite sharply to a rather broad higher maximum of between 22 and 24, at which value the rate is maintained for about 60 minutes, and finally at about 240 minutes the rate commences to decrease very rapidly. As with the NaCl and Na<sub>2</sub>SO<sub>4</sub> the lower concentration, 0.01 equivalents per 100 g. flour, generally gives the highest rate of gas production.

These curves indicate that with this formula there is no specific effect attributable to the anion. As the rate curves for the first two

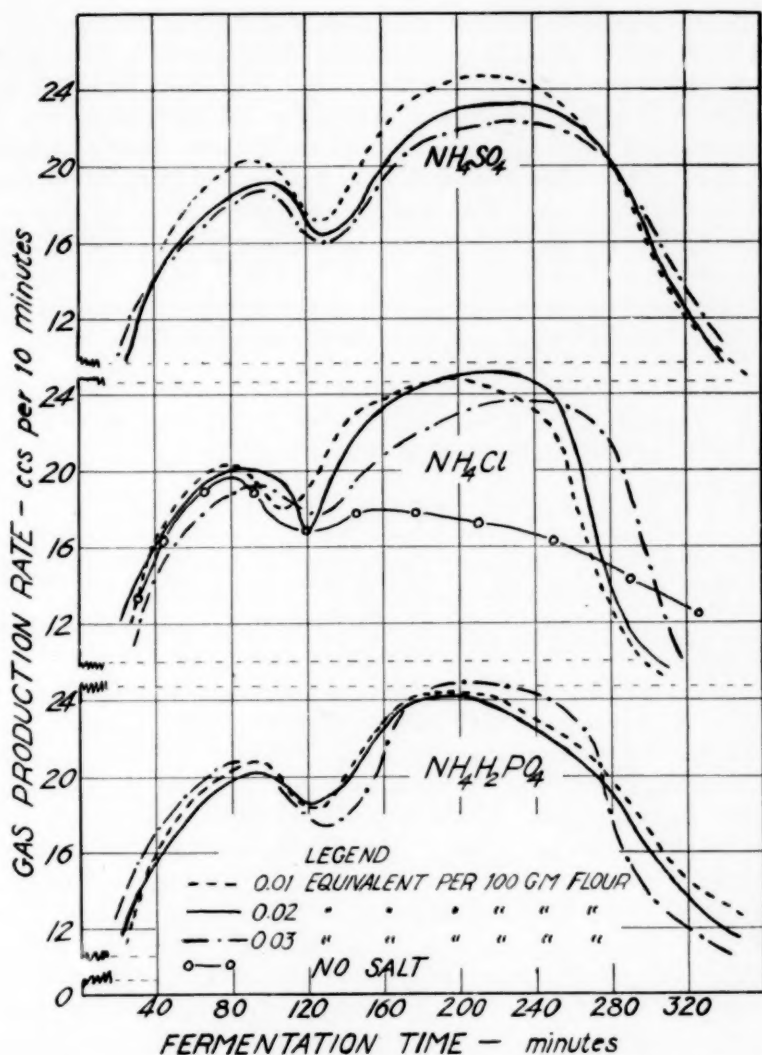


Figure 2.  $\text{CO}_2$ -production rates with different concentrations of  $(\text{NH}_4)_2\text{SO}_4$ ,  $\text{NH}_4\text{Cl}$  and  $\text{NH}_4\text{H}_2\text{PO}_4$ .

hours are similar to that obtained with  $\text{NaCl}$  and with the saltless dough, the character of the latter part of the curves must be influenced either by the cation or by the pH of the salt solutions used. The three ammonium salts used all give slightly acidic solutions but this fact alone seems insufficient to account for the observed facts, because with neutral salts such as  $\text{NaCl}$  and with unsalted doughs the initial acidity is only slightly lower than with ammonium salts, and any increase in organic acids resulting from fermentation should affect

the pH of the dough in about the same way both in the presence of neutral salts and of these ammonium salts. However, the marked differences in gassing rate observed with neutral salts and with ammonium salts as a group suggest that either the ammonium ion has a very specific effect on yeast activity or that the acidity increases more rapidly with the ammonium salt, thus creating a more favorable medium for diastasis. The similarity of the curves in Figure 2 suggests a specific effect of the ammonium ion and a negligible effect of the anions on  $\text{CO}_2$ -production.

Measurements of pH of extracts of the doughs by means of the Bailey hydrogen electrode gave the results shown in Table I.

TABLE I  
pH RANGE OF FERMENTING DOUGHS AT VARYING TIMES

	Initial	1 hr.	2 hr.	3 hr.
Doughs with neutral salts	5.6-5.7	5.4-5.5	5.2-5.3	5.1-5.2
Doughs with ammonium salts	5.4-5.5	5.1-5.3	4.7-4.9	4.2-4.5

Rumsey (1922), Mangels and Martin (1935) and others have shown that the optimum pH for diastatic activity is slightly below 5. With ammonium salts the fermenting doughs reach this optimum at about 2 hours, while with neutral salts it requires about 4 hours. Consequently with ammonium salts hydrolysis of starch in the dough ought to be approaching the maximum rate at about the time when the first decline in gassing rate becomes arrested. The second maximum of the curves in Figure 2 may then be accounted for, at least partially, by increased rate of hydrolysis of starch resulting from increase in acidity to the optimum value for diastatic activity. This does not fully explain the  $\text{CO}_2$  production rate curves because the unsalted doughs and those with neutral salts which approach the optimum acidity for diastatic activity more slowly ought to exhibit a slowly increasing rate of gassing, instead of which they decrease after a brief period of acceleration and this decrease commences while the dough is still increasing in acidity towards the optimum point for diastasis. At first sight there would appear to be a stimulating effect on the yeast due specifically to the ammonium ion, but it will be shown later that for the first two hours the rate of  $\text{CO}_2$ -production is practically the same for doughs with neutral salts and with ammonium salts. Therefore, if the ammonium ion does exert a specific stimulation on yeast activity it must be a delayed effect which comes into force about half way through the fermentation. At present no adequate explanation of these anomalies presents itself to the authors.

ACID AND BASIC SALTS— $\text{NaHSO}_4$ ,  $\text{NaH}_2\text{PO}_4$ ,  $\text{Na}_2\text{HPO}_4$ ,  $\text{Na}_3\text{PO}_4$ .  
The effects of these salts on  $\text{CO}_2$ -production are shown in Figure 3.

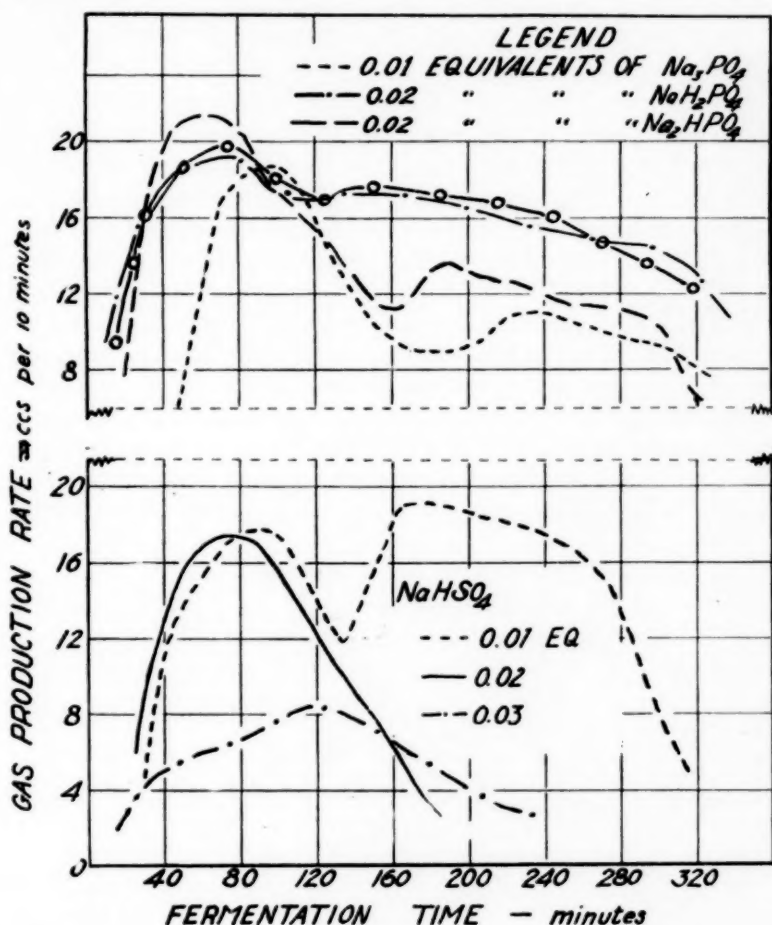


Figure 3.  $\text{CO}_2$ -production rates with different concentrations of  $\text{NaHSO}_4$ ,  $\text{NaH}_2\text{PO}_4$ ,  $\text{Na}_2\text{HPO}_4$  and  $\text{Na}_3\text{PO}_4$ .

The acid sulfate at low concentration gives a rate curve similar in character to those produced by ammonium salts, except that the maxima are lower, the first maximum being 18 and the second 19.5 as compared with 20 and 24 respectively for ammonium sulfate. With 0.02 equivalents, corresponding to 1%  $\text{NaCl}$ , there is no second maximum, the rate decreasing abruptly from the first maximum of 16 to the very low value of 2 cc. per 10 minutes at 180 minutes. Higher concentrations severely inhibit yeast activity, so that with 0.04 equivalents the rate does not rise above 2 cc. per 10 minutes.



$\text{NaH}_2\text{PO}_4$  which in solution is much less acid than  $\text{NaHSO}_4$  gives a rate curve almost coincident with that produced by an unsalted dough. This corroborates the observation previously noted that the phosphate ion has little if any specific effect on gas production.

The disodium phosphate is very slightly basic in solution. The initial maximum is somewhat sharper and higher than with the monosodium phosphate, but the rate subsequently drops lower and remains at about 30% lower than the  $\text{NaH}_2\text{PO}_4$  rate. The tri-sodium phosphate,  $\text{Na}_3\text{PO}_4$ , which is quite basic in solution, showed a very distinct lag of 30–40 minutes before there was any evidence of gas production. Then the rate rose in quite the customary manner for other salts, but reached a maximum of only about 18.5 cc.  $\text{CO}_2$  per 10 minutes. The maximum was displaced from the 60 minute point to about the 100 minute point owing to the initial lag. The ensuing decline in rate was sharper and more severe and subsequently the rate of gassing was about 10 cc. per 10 minutes. It should be noted that the curve for gassing rate with  $\text{Na}_3\text{PO}_4$  shown in Figure 3 was obtained with 0.01 equivalents of salt instead of 0.02 equivalents. With the higher dosages gas production was too slow to measure by our method.

#### Discussion of Results

It can be observed that in practically all the cases discussed the gas production rate curves are very similar for the first 80 minutes,

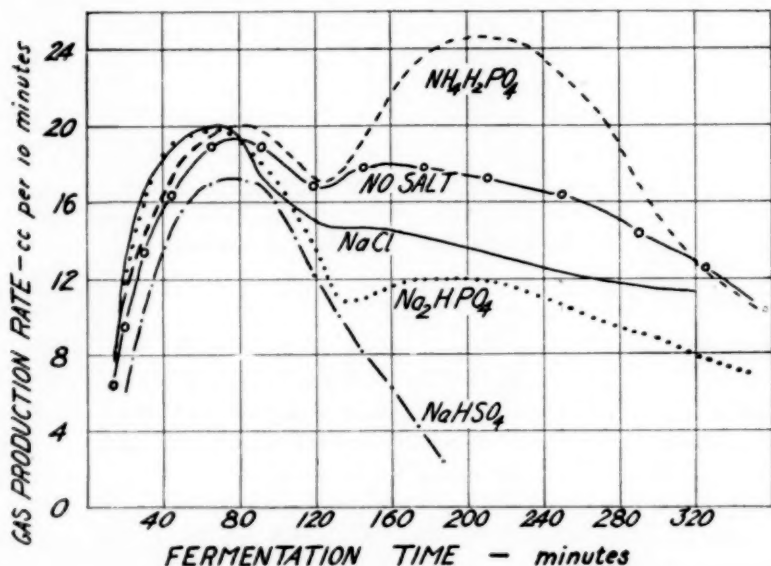


Figure 4. Comparison of  $\text{CO}_2$ -production rates obtained with  $\text{NH}_4\text{H}_2\text{PO}_4$ ,  $\text{NaCl}$ ,  $\text{Na}_2\text{HPO}_4$ ,  $\text{NaHSO}_4$  and no salt.

and thereafter a marked differentiation occurs. This is shown more clearly in Figure 4 in which rate curves with  $\text{NH}_4\text{H}_2\text{PO}_4$ ,  $\text{NaCl}$ ,  $\text{Na}_2\text{HPO}_4$ ,  $\text{NaHSO}_4$ , and no salt are reproduced. With the exception of  $\text{NaHSO}_4$ , these curves are not significantly differentiated up to 80 minutes. This part of the curve evidently represents rate of fermentation, principally of the added sucrose together with smaller amounts of maltose and glucose produced from starch by diastasis. For the first 80 minutes with the basic formula involving 3% yeast and 2.5% sucrose, the yeast seems to be the limiting factor in gas production, while for the next 40 minutes the sucrose evidently becomes the principal limiting factor. For about two hours thereafter the sugar produced by diastasis limits the fermentation rate. Beyond this four-hour period the rate declines even in the presence of free sugar and to date no means have been discovered to maintain a high gassing rate beyond this time with the standard dough formula. Evidently after about four hours the yeast activity again becomes the limiting factor in the gassing rate. If these observations are correct, one would expect that formulas having either a large amount of sucrose or none at all should give single-maximum gas rate curves.

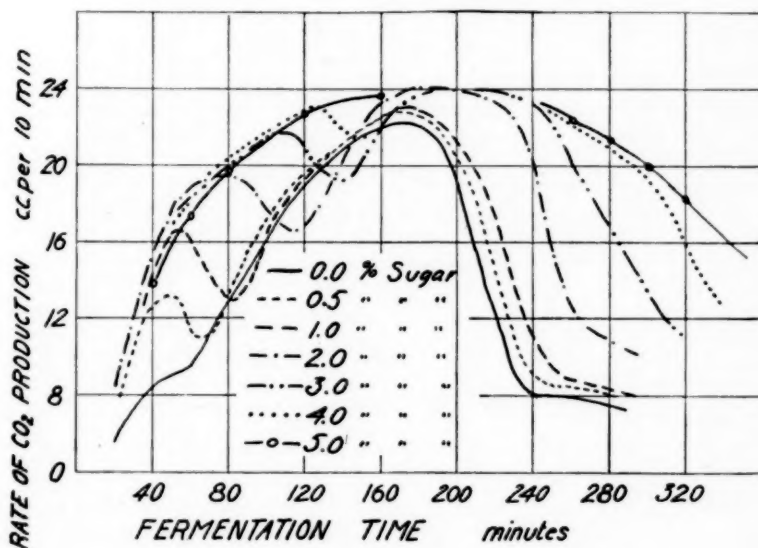


Figure 5. CO<sub>2</sub>-production rates with varying amounts of sucrose.

The data shown graphically in Figure 5 confirm this surmise. The various rate curves were obtained with doughs differing only in the amount of added sucrose. With the unsugared dough the yeast must depend on the small amount of free sugar in the flour and the sugar

produced by diastasis. This curve is quite regular and has only one maximum. With 0.5% sucrose in the formula there is a more rapid initial increase in rate followed by a slowing down and then an acceleration comparable to that observed with the unsugared doughs. Large dosages of sucrose merely accentuate the first maximum. In view of these facts it was surmised that the first maximum was characteristic of a system in which there was, for a time, an excess of the easily hydrolysable sucrose over yeast requirements and that similar effects ought to be obtained with glucose and fructose but not with maltose.

This was confirmed by experiments in which 2.5% dosages of sucrose, glucose, fructose, and maltose respectively were used in the dough formula with 0.002 equivalents of  $\text{NH}_4\text{H}_2\text{PO}_4$ . The rate curves for these doughs are given in Figure 6. It would be expected that the

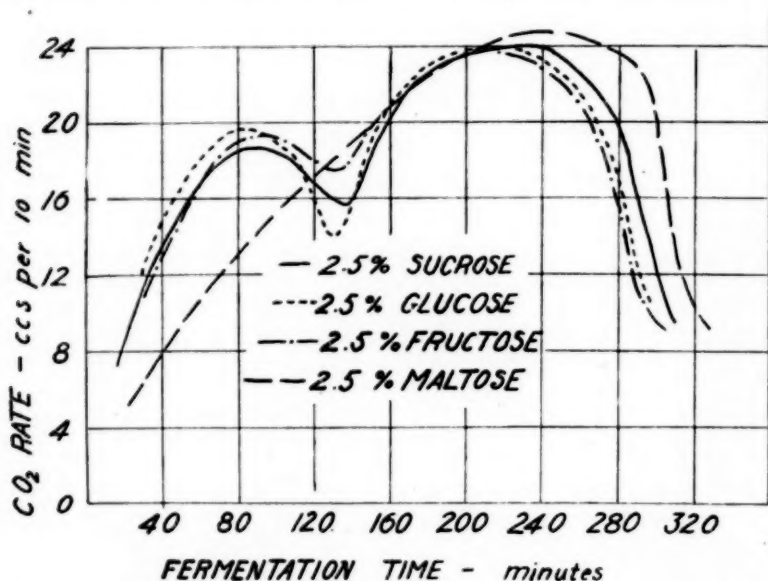


Figure 6.  $\text{CO}_2$ -production rates with 2.5% dosages of sucrose, glucose, fructose and maltose.

minima would be practically on the maltose rate curve, but they dipped below it. No explanation of this is forthcoming at present. The curves show that sucrose, on account of its great ease of hydrolysis, is nearly as completely available to the yeast as the glucose or fructose. The single-maximum curve given by maltose can also be obtained with various dosages of this sugar. As the concentration of maltose increases the only effect is that the maximum is shifted further along in time.

The foregoing data seem to warrant the conclusion that salts have little if any specific effect on the fermentation during the first two hours. During this initial period the rate of gas production is determined almost entirely by the concentration of sucrose or glucose and the amount of yeast. It is only after the sugar concentration decreases far enough to become the limiting factor that there is any marked differentiation between various salts. This holds true even for flours of widely different diastatic activity, as can be seen in Figure 7.

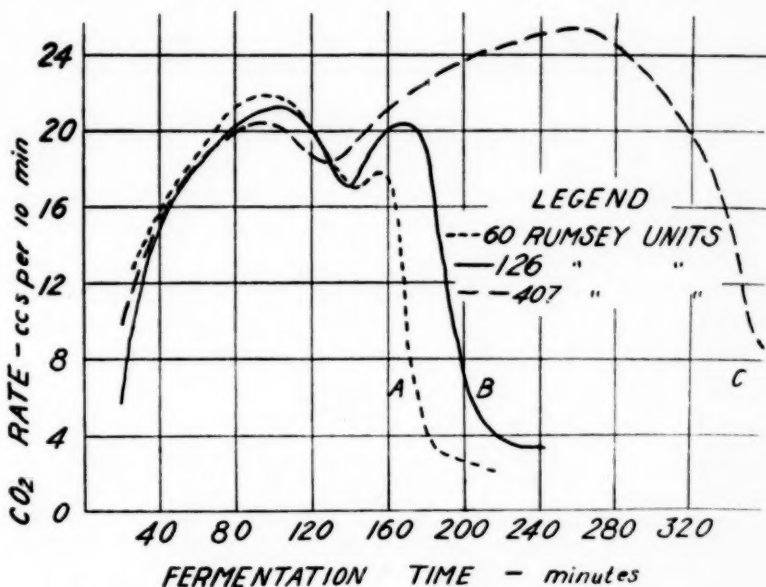


Figure 7. CO<sub>2</sub>-production rates with three flours of different diastatic activity.

Flours of 60, 126, and 407 Rumsey units respectively gave practically the same gas rates during the first two hours. Only after the rate started declining from the first maximum were they differentiated. It looks as if the yeast shows a specific preference for sucrose. Even though the pH of the flours represented in Figure 7 are not at the optimum for diastase, they are fairly close to it and it is reasonable to suppose that with the great differences in diastatic activity there should be more maltose produced in Flour C during the first two hours than in Flour A. Yet during this period the gas rates are practically the same for these two flours. They both show decreases in rate followed by increases. The differences in diastatic activity are exhibited only in the different times over which the increased rate is maintained.

### Summary

By replacing NaCl entirely the effects of other salts on gas production can be satisfactorily studied. It was found that such widely different salts as  $\text{Na}_2\text{SO}_4$ ,  $\text{NaH}_2\text{PO}_4$ ,  $\text{Na}_2\text{HPO}_4$ ,  $\text{NH}_4\text{Cl}$ ,  $\text{NH}_4\text{H}_2\text{PO}_4$ ,  $(\text{NH}_4)_2\text{SO}_4$ , when used in dosages equivalent to 1.12% NaCl in the basic formula, show practically no differentiation in  $\text{CO}_2$ -production rates for the first two hours of the fermentation period. Thereafter very great differences occur.

The ammonium salts all gave similar gas-rate curves, characterized by a secondary acceleration to a high rate which was maintained for about  $1\frac{1}{2}$  hours. These results seem to be due specifically to the ammonium ion.

The initial rise and dip in the gas-rate curves was shown to be attributable to the ease of hydrolysis of the sucrose; glucose and fructose give similar results, while maltose gives a single-maximum rate curve; doughs with high initial sucrose and doughs with no added sucrose give single-maximum curves.

The fermentation rate during the first two hours was practically unaffected by either the kind of salt used or the diastatic activity of the flour, other factors being constant.

### Literature Cited

Brockington, S. F.

- 1932 A study of the experimental testing of flours and of the properties of wheat flour dough in relation to flour strength.—Thesis filed in the Chemistry Department, University of Saskatchewan.

Larmour, R. K., and Brockington, S. F.

- 1934 Studies on experimental baking tests. I. Effects of variation in baking formulas on gas production and loaf volume. *Cereal Chem.* **11**: 452-470.

Mangels, C. E., and Martin, J. J., Jr.

- 1935 Effect of different buffers and types of substrate on the diastasis of wheat starch. *Cereal Chem.* **12**: 256-268.

Rumsey, L. A.

- 1922 The diastatic enzymes of wheat flour and their relation to flour strength. *Am. Inst. Baking Bull.* **8**.



## THE DISAPPEARANCE OF FLAVORS IN BISCUITS

R. S. GILMER, D. E. KINDER, and R. M. BOHN<sup>1</sup>

The Technical Institute of The Independent Biscuit Manufacturers' Company,  
325 W. Huron Street, Chicago, Illinois

(Received for publication June 15, 1936)

It has long been recognized that added flavors largely or wholly disappear during the manufacture of biscuits. It should be made clear that by the term biscuits reference is not to baking powder biscuits but to wafers, shortbreads, arrowroot biscuits, spice drops, and the similarly small, relatively dry cookies made by biscuit and cracker manufacturers.

The disappearance of flavors such as vanilla, lemon oil, orange oil, and the spices, has often been ascribed to the high baking temperatures used and to the fact that such products are usually baked to moisture contents far lower than for soft cakes. Oxidation has also been an explanation of this flavor loss.

At a meeting of the American Society of Bakery Engineers in March 1933, A. A. Schaal presented data showing that soft cakes containing chocolate or cocoa have the best color and flavor when the pH of the finished cake is 7.5 to 7.8. Schaal's work was based upon the summation of several factors such as grain, texture, flavor, and color. As a result of an extended investigation,<sup>2</sup> using flavor as the sole criterion for scoring, it has been found that hard sweet biscuits have the finest chocolate flavor when the pH is between 6.7 and 7.3. This was true for all of the cocoas or chocolate liquors used, some 14 in number. It seemed logical then to repeat this work on added flavors such as pure vanilla, vanillin, ethyl vanillin, coumarin, the spices, lemon, orange, butter, honey, and high-grade molasses.

The manufacturer of biscuits seldom, if ever, uses a prepared baking powder. He adds baking soda, cream of tartar, and ammonium carbonate or bicarbonate to his doughs. Since an excess of soda substantially improves the texture and appearance of his products, and permits of a lesser proportion of the more expensive ingredients (eggs, shortening, and sugar), it has been common practice to use enough soda to bring many, if not most, biscuits to a pH of 7.0 or over. Indeed, in the case of certain biscuits such as honey jumbles,

<sup>1</sup> Acknowledgment is made to Olive Crane of the Technical Institute, for helpful suggestions and aid throughout this work in judging the odor of the biscuits.

<sup>2</sup> Unpublished data.

it has not been possible, at least up to the present, to produce texture and appearance characteristics even remotely resembling those desired when the pH of the cooky drops below 7.0.

For this work we chose four widely different types of cookies. The basic formulas used are shown in Table I.

TABLE I  
BASIC FORMULAS USED IN THE INVESTIGATION

Type of cooky	Short-bread	Hard Sweet (arrow-root)	Wafer	Honey Jumble
Dough consistency	Stiff, dry	Stiff, dry	Soft	Medium
Forming machine (in plant production)	Rotary	Cutting machine	Wire cut	Wire cut
Flour, %	100	100	100	100
Shortening, %	35	25	30	5
Sugar, %	30	50	75	15, + 70 invert syrup
Salt, %	1	1	1	1
Water, %	6	15	65	20
Soda ( $\text{NaHCO}_3$ ), %	Variable	Variable	Variable	Variable

Biscuits were made from these formulas with variations in soda from none to 1.25% based on flour. In any one series the flavor was added to each dough in identical amount, the quantities used being the same or higher than those used commercially. The only variation in the doughs was the soda. The doughs were made in laboratory-sized batches, formed by hand (rolling and cutting for hard doughs, bagging for soft ones), and baked as uniformly as possible. When cooled for the same length of time after baking, the biscuits were stored in clean cans having tight covers. The next day they were examined for odor and flavor, with passing attention paid to the texture and color. pH was determined electrometrically, using the quinhydrone electrode. In every case the biscuits were submitted to several people for independent judgment. In many cases they were examined by others than our own staff, including several experts on flavors, at periods ranging from two weeks to two months after baking. Since the comparative findings were the same up to two months of age of the biscuits, no attempt will be made to give more than one set of results for any series of bakes. The analytical data recording the various tests will be found in Tables II to VII inclusive.

Additional data could be presented, but they would only confirm the results shown in Tables II to VII. Shortbreads and honey jumbles gave results duplicating those found with the hard sweets and vanilla wafers. The natural flavors of honey and high-grade molasses act similarly in disappearing at pH's of over 7.0.

TABLE II  
TESTS WITH HARD SWEET BISCUITS USING LEMON AND ORANGE OIL

Lab. No.	Leavening added	Flavor added	pH of cooky	Character of added flavor	Appearance, texture of cooky
<i>Series I</i>					
21 A	No soda, 0.1% tartaric acid	0.3% lemon oil <sup>1</sup>	5.2	Strong, excellent	Pale, close, flinty
22 A	None	0.3% lemon oil <sup>1</sup>	5.6	Strong, excellent	Pale, close, flinty
23 A	0.1% soda	0.3% lemon oil <sup>1</sup>	6.4	Good, weaker	Quite pale
24 A	0.3% soda	0.3% lemon oil <sup>1</sup>	7.0	Weak, off odor	Normal, open texture
25 A	0.5% soda	0.3% lemon oil <sup>1</sup>	7.5	Very bad, no lemon	Dark
26 A	0.8% soda	0.3% lemon oil <sup>1</sup>	8.1	Very bad, no lemon	Very dark, burned
<i>Series II</i>					
31 A	No soda, 0.1% tartaric acid	0.3% orange oil <sup>2</sup>	5.2	Strong, excellent	Pale, close
32 A	None	0.3% orange oil <sup>2</sup>	5.8	Strong, excellent	Pale, close
33 A	0.1% soda	0.3% orange oil <sup>2</sup>	6.3	Good, weaker	Quite close
34 A	0.3% soda	0.3% orange oil <sup>2</sup>	7.0	Fair, weak	Normal, open texture
35 A	0.5% soda	0.3% orange oil <sup>2</sup>	7.6	Poor, very little orange	Dark
36 A	0.8% soda	0.3% orange oil <sup>2</sup>	8.3	Poor, no orange	Very dark, burned

<sup>1</sup> Lemon oil used was Messina hand-pressed.<sup>2</sup> The orange oil was sweet Messina hand-pressed.

All of the batches were repeated using 0.5% lemon and orange oils. The results were identical.

TABLE III  
TESTS WITH HARD SWEET BISCUITS USING DIFFERENT KINDS OF VANILLA FLAVORING

Lab. No.	Leavening added	Flavor added	pH of cooky	Character of added flavor	Appearance, texture of cooky
<i>Series III</i>					
41	0.1% tartaric acid	5% imitation vanilla <sup>1</sup>	5.1	Excellent	Close, hard, pale
42	None	5% imitation vanilla <sup>1</sup>	5.8	Excellent	Close, hard, pale
43	0.1% soda	5% imitation vanilla <sup>1</sup>	6.5	Fair	Slightly more open
44	0.3% soda	5% imitation vanilla <sup>1</sup>	7.2	None	Normal, open, dark
45	0.5% soda	5% imitation vanilla <sup>1</sup>	7.3	None	Normal, open, dark
46	0.8% soda	5% imitation vanilla <sup>1</sup>	7.8	None	Very dark (burnt)

TABLE III—Continued

## Series IV

51	0.1% tar- taric acid	5% pure vanilla <sup>2</sup>	5.2	Delightful	} as with the 41 series
52	None	5% pure vanilla <sup>2</sup>	5.8	Good	
53	0.1% soda	5% pure vanilla <sup>2</sup>	6.3	Almost gone	
54	0.3% soda	5% pure vanilla <sup>2</sup>	6.9	Little or none	
55	0.5% soda	5% pure vanilla <sup>2</sup>	7.2	None	
56	0.8% soda	5% pure vanilla <sup>2</sup>	7.5	None	

<sup>1</sup> Imitation vanilla flavor was made by dissolving 0.5 g. vanillin and 0.06 g. coumarin in 100 cc. distilled water. This equals pure vanilla in strength.

<sup>2</sup> Pure vanilla was a U.S.P. vanilla extract.

TABLE IV

## TESTS WITH HARD SWEET BISCUITS USING VARIOUS SPICES

Lab. No.	Soda added	Flavor added	pH of cooky	Character of added flavor	Appearance, texture of cooky
61	None	1.5% ginger	5.1	Strong, good	Close, hard, pale
62	0.3%	1.5% ginger	5.8	Weaker	Close, hard, pale
63	0.6%	1.5% ginger	8.2	Very weak	Open, very dark
71	None	1.5% cinnamon	5.9	Strong	} like cookies of com- parable pH above
72	0.3%	1.5% cinnamon	6.7	Weak	
81 <sup>1</sup>	None	Butter used as shortening	5.7	Delightful	
83 <sup>1</sup>	0.6%	Butter used as shortening	7.2	Very poor	

<sup>1</sup> Butter used as shortening in 81 and 83.

TABLE V

## TESTS WITH WAFERS USING DIFFERENT KINDS OF VANILLA EXTRACT

Lab. No.	Soda added	Flavor added	pH of cooky	Character of added flavor	Appearance, texture of cooky
102 A	None	2.5% fortified vanilla <sup>1</sup>	6.3	Excellent, strong	Very pale, close, "brown-edge"
104 A	0.25%	2.5% fortified vanilla <sup>1</sup>	6.7	Good	Pale, close, "brown-edge"
105 A	0.375%	2.5% fortified vanilla <sup>1</sup>	6.8	Fair, weak	Rather pale, slightly "brown-edge"
106 A	0.5%	2.5% fortified vanilla <sup>1</sup>	6.8	Very weak	Normal, open, tender
107 A	0.625%	2.5% fortified vanilla <sup>1</sup>	7.0	None	Normal, open, tender
108 A	0.75%	2.5% fortified vanilla <sup>1</sup>	7.1	None	Normal, open, tender
109 A	0.875%	2.5% fortified vanilla <sup>1</sup>	7.1	None	Normal, open, tender
110 A	1.0%	2.5% fortified vanilla <sup>1</sup>	7.1	None	Normal, open, tender

<sup>1</sup> Fortified vanilla flavor was made by adding to U.S.P. vanilla sufficient vanillin and coumarin in the ratio of 10 parts vanillin and 1 part coumarin to make a 4-fold flavor. 0.5% ammonium bicarbonate added to each batch as additional leavening agent. Also eggs and milk used in these doughs; these gave the doughs a high buffer effect.

TABLE VI  
TESTS WITH WAFERS USING VARIOUS FLAVORS<sup>1</sup>

Lab. No.	Leavening added	Flavor added	pH of cooky	Character of added flavor	Appearance, texture of cooky
111	0.25% cream of tartar	Lemon oil	6.5	Excellent, strong	Pale, close, "brown-edge"
112	1.0% soda	Lemon oil	7.0	Poor, almost none	Normal, open, brown
121	0.25% cream of tartar	Orange oil	6.2	Excellent, strong	as with cookies of comparable pH above
122	1.0% soda	Orange oil	7.0	Poor, almost none	
131	0.25% cream of tartar	Butter used as shortening	6.5	Excellent	
132	1.0% soda	Butter used as shortening	7.5	Poor	

<sup>1</sup> Eggs and milk also used.

TABLE VII  
TESTS WITH HARD SWEET BISCUITS USING VARIOUS FLAVORS

Lab. No.	Soda added	Flavor added	pH of cooky	Character of added flavor	Appearance, texture of cooky
141	None	Ethyl vanillin	6.0	Excellent	as above for cookies of similar pH
142	0.8%	Ethyl vanillin	7.9	Poor, gone	
151	None	Coumarin	5.9	Good	
152	0.8%	Coumarin	7.8	Good	
161	None	Vanillin	6.0	Good	
162	0.8%	Vanillin	7.9	None	

### Discussion

The findings shown above are almost self-explanatory. It will be noted that, coumarin excepted, all flavors added to cooky doughs were strong, true to type, and of delightful character whenever the biscuit showed a pH of 6.5 or less. Between pH 6.5 and 7.0 the flavors were progressively weaker and practically disappeared in the neighborhood of pH 7.0. At pH's of over 7.0 all flavors except coumarin were almost entirely destroyed. The flavors used included pure vanilla, vanillin, ethyl vanillin, oil of lemon, oil of orange, ginger, cinnamon, butter, honey, and molasses. Several doughs made on a commercial scale in a biscuit plant have completely confirmed the laboratory results.

It is not maintained here that flavors are not lost during baking, regardless of the pH of the dough and biscuit. They are lost, as anyone can testify who has baked biscuits either under laboratory or plant conditions. The odor in the neighborhood of the oven is ample proof that large flavor losses occur by volatilization. But in all cases



where the biscuits had a pH of less than 6.5, a substantial portion of the flavor remained in the biscuit.

The remedy for this almost complete flavor loss is not merely removal of all or part of the soda from the biscuit formula. Any such arbitrary and drastic change will profoundly alter the texture and appearance of the biscuit, in almost all cases for the worse. Experiments have been made with large amounts of ammonium bicarbonate, with buffers such as the phosphates, and with formula changes, in an effort to produce a wafer of normal texture and appearance with a pH under 7.0—and in all cases quite unsuccessfully. Although it is not contended that the solution of this problem is impossible, it apparently will not be easy.

Shortbreads can be made acid, with a good texture and appearance, if extra shortening and sugar and perhaps invert syrup are used. Cutting-machine biscuits can also be made acid by proper formula adjustments, although even then the biscuits will be altered in texture and appearance. Wire-cut goods other than wafers are modified in texture and appearance very decidedly when the pH is changed; moreover, the spread is lessened materially. Honey jumbles and honey cakes, which are chiefly flour and invert syrup, are so changed with reduced soda as to be unrecognizable and quite inedible, being small, very close, tough, and hard.

There are several ways, however, in which these findings may be used. Where it is known that biscuits are to have a pH over 7.0, or perhaps over 6.8, there is little object in adding flavors, coumarin excepted. In certain instances, biscuits may be made acid by suitable formula changes and thus have greatly enhanced flavor. It was found, indeed, that even when no flavor was added, the natural flavor of the acid biscuit was far superior to that of the alkaline one. Alkaline biscuits have a disagreeable, burnt, sometimes "strawy" odor and flavor. This work also makes possible the deliberate production of a line of cookies of flavor much superior to most of those produced at present.

While we have made no attempt to determine in just what way the soda destroys flavors, there are at least two logical explanations with sound theoretical bases. Most flavors are aldehydes. The well known Cannizzaro reaction is the conversion of aldehydes by alkalis into the corresponding alcohols and acid salts. In the case of flavors, the aromatic aldehydes may be converted into the odorless alcohols and acid salts. Coumarin being a lactone of coumarinic acid, is less affected than the other flavors. Another possibility is the resinification or condensation of the aldehydes.

### Summary

Flavors and flavoring materials such as pure vanilla, vanillin, ethyl vanillin, ginger, cinnamon, lemon oil, orange oil, butter, honey, and molasses, when added to biscuit doughs, are destroyed if the pH of the biscuits is over 7.0. Between pH 6.5 and 7.0 they are weakened and changed in character. When the biscuit has a pH of less than 6.5, the flavor is retained in the biscuit in substantial amounts and with unchanged character.

## RELATION OF AMYLASE ACTIVITY TO GASSING RATE <sup>1</sup>

EMIL MUNZ and C. H. BAILEY

Division of Agricultural Biochemistry, University of Minnesota, St. Paul, Minnesota

(Received for publication January 29, 1936)

Bread baking practices followed in the United States commonly involve the use of sugar in the dough. It is probable that the total fermentable sugars thus added in the form of sucrose, glucose, malt products (extract, flour, *etc.*), and otherwise average in the range of 4 to 5% of the weight of flour used. In addition, the flour commonly contains upwards of 1.5% of such sugars, chiefly in the form of sucrose. This raises the question: When, in the progress of fermentation of such bread sponges and doughs does the sugar supply become sufficiently depleted so that the rate of production of the gases of fermentation (here referred to as "gassing rate") becomes appreciably reduced? The study here reported was designed to contribute to an answer to this question.

In American bakeries both sponge and straight dough methods are employed. The sponge method commonly involves the preliminary fermentation for several hours of a mixture of a portion of the total flour of the final batch plus water and yeast. When its fermentation is concluded after four or more hours it is remixed with the remaining flour plus water, salt, sugar or syrups containing sugars, and other dough ingredients. This dough is then fermented for a relatively short period, made up into loaves and baked after suitable proofing in the pan. In the straight dough process all the dough ingredients are added to the initial batch, which is then subjected to the one mixing operation. This dough is then fermented for upwards of  $5 \pm$  hours, divided, molded, proofed, and baked.

To determine the relative gassing rate in a simple sponge, two

<sup>1</sup> Paper No. 1409, Journal Series, Minnesota Agricultural Experiment Station. Condensed from a thesis presented to the Graduate School of the University of Minnesota by Emil Munz, in partial fulfillment of the requirements for the degree of Doctor of Philosophy, 1935.

bread flours were employed which had previously been compared and characterized as normal, and low in diastatic activity respectively. Two types of sponges were used in each instance, one in which the yeast represented  $3\frac{1}{3}\%$  of the weight of flour, and in the second just half as much or  $1\frac{5}{6}\%$ . These proportions of yeast, incidentally, would have supplied just 2% and 1%, respectively, in the final dough of which the sponges would normally have become a part.

Through the use of a Brabender fermentograph, the gas production was observed for each of these four doughs with the results recorded graphically in Figure 1. Using the relative slope of the graphs as

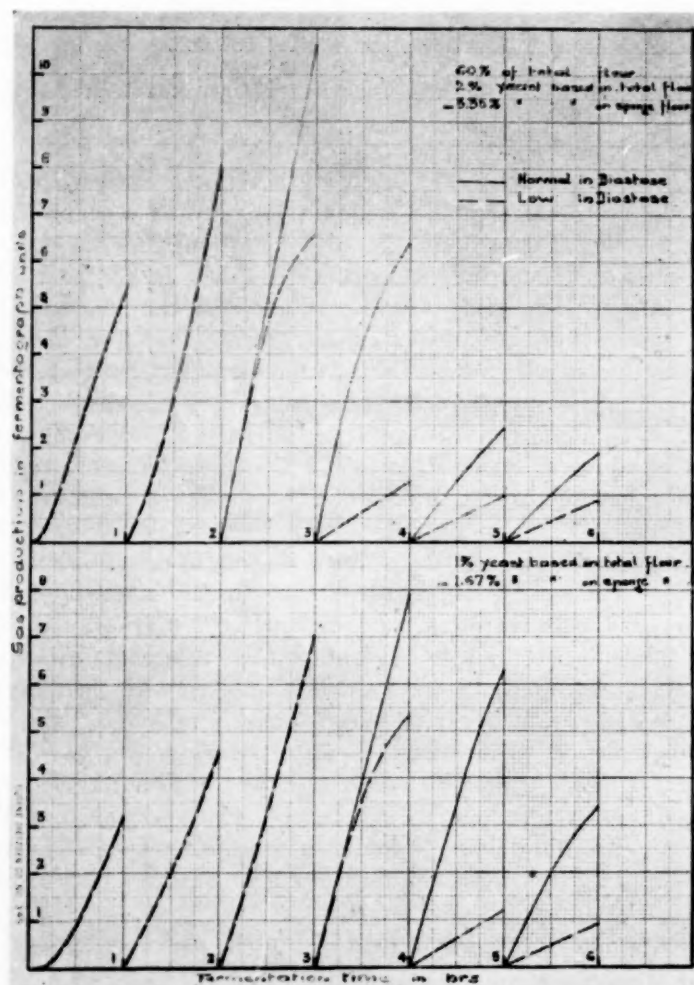


Figure 1. Rate of fermentation in fermentograph units of a sponge made from a normal diastase flour (solid lines) and a low diastase flour (broken lines) containing  $3\frac{1}{3}\%$  yeast (above) and  $1\frac{5}{6}\%$  yeast (below), respectively.

an index of gassing rate it is apparent that this rate was fairly constant well into the fourth hour in the instance of the normally-diastatic flour sponge made with 3-1/3% yeast, and for more than an hour longer when only 1-5/6% yeast was employed.

With the low diastatic flours the gassing rate perceptibly diminished toward the close of the third hour in the 3-1/3% yeast sponge, and was very low as this sponge entered the fourth hour. When half as much yeast was present, *viz.*, 1-5/6%, the reduction in gassing rate was delayed an hour, and reached the low level at the beginning of the fifth hour.

It thus appears that sponges made with normally diastatic flours and the usual yeast dosages may be expected to maintain a sustained gas production for several hours. Obviously, low diastatic flours become exhausted sooner in terms of fermentable sugar supply. The real significance of such diminishing gassing rates must be considered in terms of other concurrent events, however. Gas production is not the only expression of the processes which contribute to the appropriate aging or ripening of the sponge. Increasing H-ion concentration, progressive hydration of the hydrophylic colloidal constituents of the flour, and possibly actual hydrolysis of flour proteins are doubtless reflected in the sum total of physical changes in dough properties which accompany the yeast fermentation. The heterogeneous system encountered in doughs is so complex as to render difficult the quantitative estimation of the effect of these several variables.

It is well known that patent flour doughs change in pH fairly rapidly during the initial stages of fermentation. To afford an indication of the effect of increased H-ion concentration, simple flour-water doughs were acidulated with 0.01M citric acid until the pH was adjusted to 5.2. A series of such doughs were prepared in the farinograph, by means of which the relative plasticity could be observed. These doughs were allowed to rest for varying lengths of time, as recorded on the graphs in Figure 2 and then remixed. On comparing these farinograph curves it appeared that the mobility of the doughs increased as a function of time, as was registered in terms of the downward slope of the curves in departing from the horizontal. Also, the maximum point of the curves was depressed in progressing through the series of increasing time intervals. From this it might be deduced that pH changes in doughs can be expected to register in terms of the sum-total of changes in physical properties that is characterized as aging. This further suggests that the combination of time and increased acidity may contribute effectively to the aging and maturing process in sponges even though gassing rate is decreased with exhaustion of fermentable sugars.

When sponges are converted into doughs, or when straight doughs are mixed, it is customary in this country to add appreciable quantities of sugar. Subsequent gas production can be assumed to be due largely

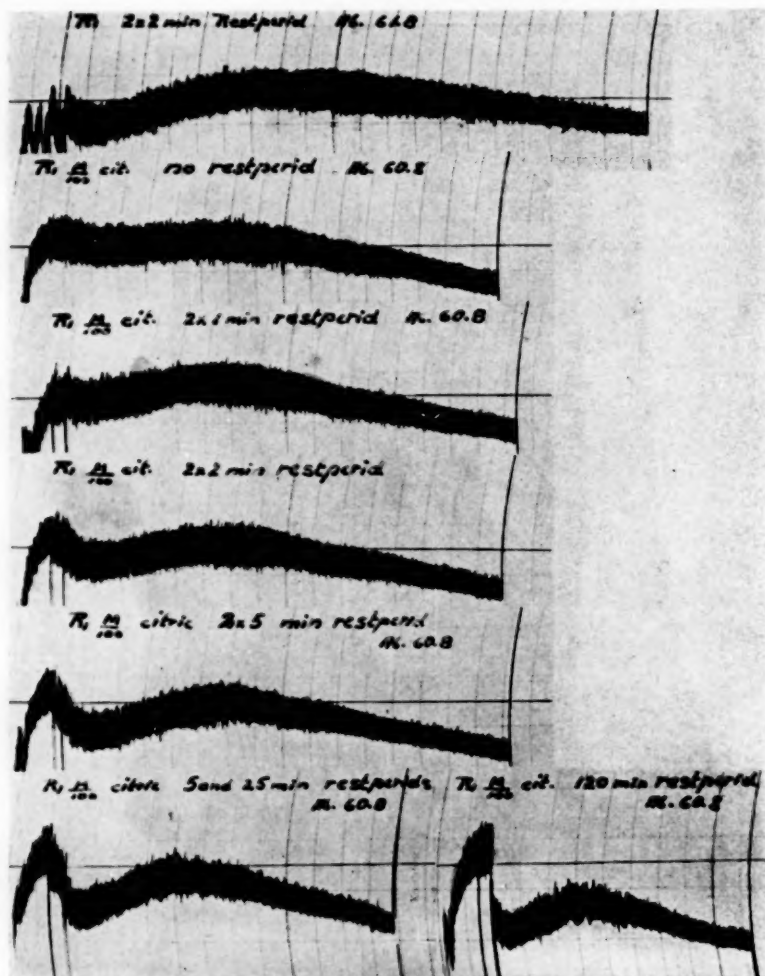


Figure 2. Simple flour-water doughs mixed in the farinograph and brought to pH = 5.2 with citric acid. Rest periods from 0 to 120 minutes were allowed, the doughs remixed and the farinograph curve presented as a measure of the effect of time upon the plasticity of acidulated doughs.

to two variables, (1) the actual quantity of sugar in the dough at the outset and (2) the relative diastatic activity which determines the rate at which fermentable sugars are produced during the progress of fermentation.

Sponges were converted into straight doughs to which 0%, 3%, and 6% of sucrose were added. These sponge doughs were prepared with



the same two flours that were previously assayed as normal, and low in diastatic activity. The fermentograph records which resulted from a study of these several doughs appear in Figure 3. In the instance of

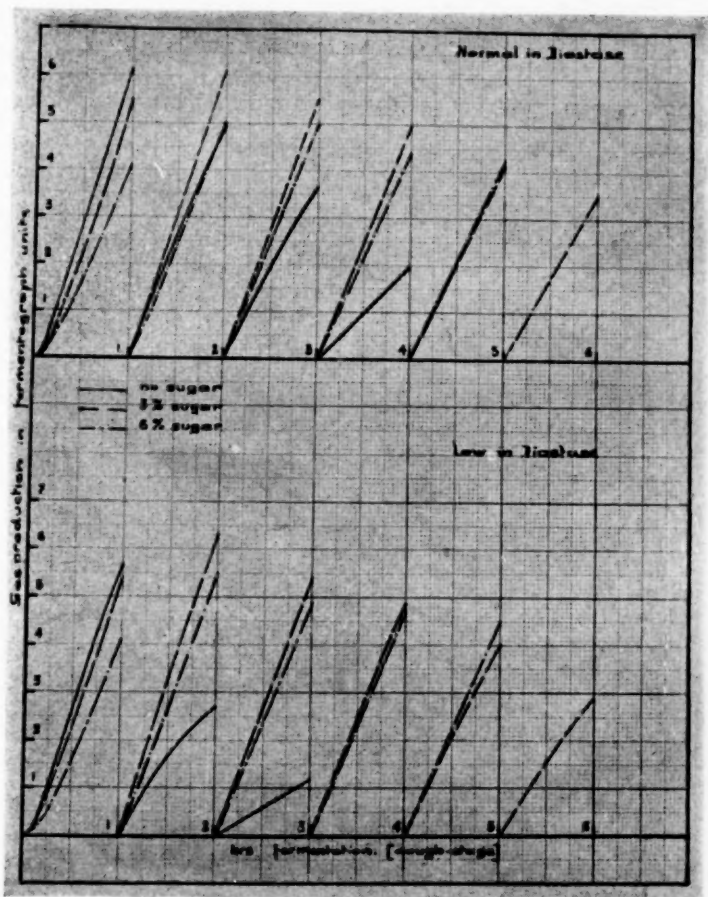


Figure 3. Rate of fermentation in fermentograph units of sponge doughs made from a normal-diastase flour (above), and a low diastase flour (below) containing 0%, 3%, and 6% added sucrose respectively.

the normal diastase group (upper half of figure) there was little difference in gassing rate between the two doughs which contained 3%, and 6% of sugar. Their gassing rate, moreover, maintained fairly uniform through four hours of fermentation, which is substantially longer than the usual time of fermentation allowed such doughs in bakery practices. In the dough prepared without sugar (the solid line in the graphs) the gassing rate began to diminish perceptibly in the third hour and had reached a low level by the end of the fourth hour. Whether or not

this is significant becomes very obviously a question of the baker's practices.

The sponge-doughs made with the low-diatase flour did not differ greatly in gassing rate from the normal-diatase flour doughs when 3% or 6% of sucrose was included in the formula. It was not until the close of the fourth hour that any substantial reduction in gassing rate was registered. As might be anticipated the doughs made without sugar decreased in gassing rate earlier in the fermentation period than was true with the normal-diatase flour. Thus, during the second hour the gassing rate began to diminish substantially as indicated by the solid lines in the lower half of Figure 3.

Straight doughs were then investigated in like manner. Four levels of sugar were involved, namely, 0%, 3%, 6%, and 10%, based upon the weight of flour in the batch. The same two flours were employed as before, one of them normal in diastatic activity, the other low in that particular. The gassing rates through 7 hours of fermentation are recorded graphically in Figure 4. Initial gassing rate through the first 20 to 30 minutes was low as thus determined, due, no doubt, to the fact that much of the  $\text{CO}_2$  produced was being dissolved in the water of the dough and hence did not register in terms of dough expansion. With the flour that was normal in diastatic activity there was no substantial difference in gas production through 6 hours of dough fermentation.

During the seventh hour the rate for the sugar-free dough diminished by the order of about 50%, and that of the 3% sugar dough to a significant extent. This is a long fermentation period that is considerably beyond the normal for commercial bread production, however.

In the instance of the low diastase flour doughs, the gassing rate of the sugar-free dough diminished by the order of 60% during the fourth hour, but the doughs containing 3 to 10% sugar continued their original rate through the sixth hour or longer.

An extended series of baking tests was then conducted involving eight hard wheat patents ranging around .41% ash and including three hard spring wheat patents containing 12.6%, 12.8%, and 13.3% of crude protein respectively, two blended hard spring and winter wheat patents containing 11.5% and 11.85% crude protein respectively, and three hard winter wheat patents containing 10.9%, 11.5%, and 12.3% of crude protein respectively. Without reporting the extensive baking data in detail, it appeared that when commercial formulas and baking practices were followed, the bread scores were higher when diastatic activity was adjusted with wheat malt flours than when sucrose additions alone were made to provide fermentable

carbohydrates. The exact reasons for this improvement with malt are not entirely apparent from these studies. Whether or not such considerations as a more constant level of fermentable sugars, or an

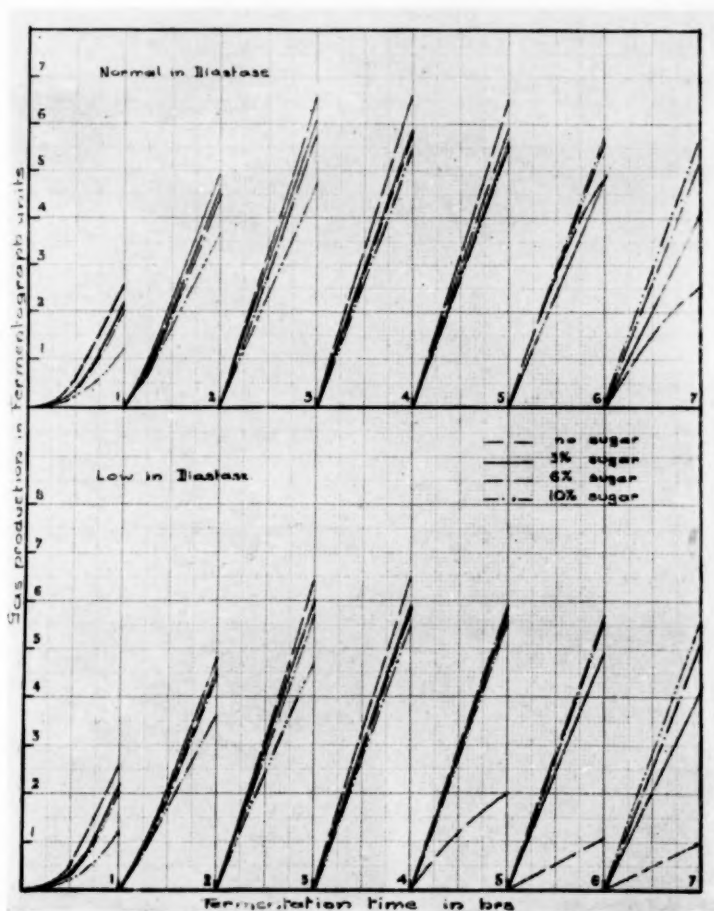


Figure 4. Rate of fermentation in fermentograph units of straight doughs made from a normal-diastase (above) and a low diastase flour (below) and containing 0%, 3%, 6%, and 10% of added sucrose respectively.

effect of proteinases, or yeast nutrients are involved in these useful malt effects can be disclosed only by additional detailed researches. The fact remained, however, that the inclusion of small proportions of active wheat malt resulted in superior bread in the instance of all of the eight flours employed than when refined cane sugar alone was used in the doughs.

It is known that the solids of skim-milk tend to buffer a dough,

thus reducing diastatic activity. An experiment was included in this study which involved the addition of 6% of dry skim-milk to various doughs. Sponge doughs were thus prepared with and without milk, and this pair without sugar and with 3% of sugar. The gassing rates of such doughs made with the normal, and the low diastase flours through 3 hours of fermentation are recorded in Figure 5. It ap-

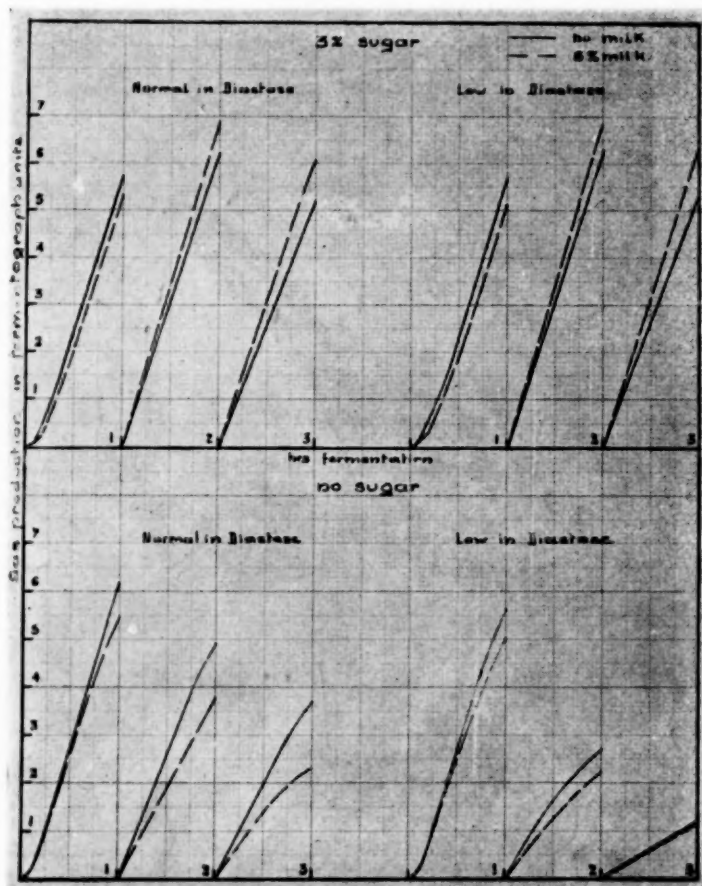


Figure 5. Rate of fermentation in fermentograph units through 3 hours of sponge doughs made from a normal-diastase flour (left half) and low in diastase (right half), containing 0% and 3% added sugar (below and above) and with no dry skim-milk (solid lines) and 6% dry skim-milk respectively.

peared that the rate of gas production was increased somewhat when sugar was used, but was reduced in the "no-sugar" sponge doughs, as might be anticipated from the effects of milk solids mentioned above.

A similar study was made with straight doughs to which 3 parts of sugar per 100 parts of flour had been added. The resulting data are

recorded in Figure 6. Again the presence of the milk solids tended to stabilize the gassing rate through the six or seven hours that the doughs were observed. Evidently certain milk constituents tend to accelerate

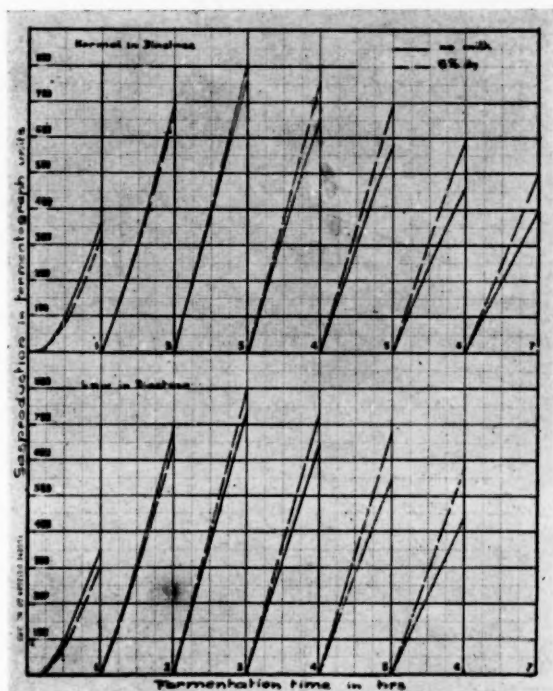


Figure 6. Rate of fermentation in fermentograph units of straight doughs made from a normal-diastase flour (above) and a low diastase flour (below), with 3% of added sucrose in all cases, and with no added milk (solid lines) and 6% dry skim-milk (broken lines) respectively.

yeast fermentation in bread doughs and particularly when an abundance of fermentable sugars is present.

### Summary

In bread sponge doughs to which no sugar was added the gassing rate is a function of time, diastatic activity, and proportion of baker's yeast. The rate was fairly constant for four or more hours when the flour used was normal in diastatic activity, and an hour or more less when a low-diastase flour was employed.

In bread doughs an additional variable appears, namely, the proportion of sugar in the formula. When 3 parts or more of sugar per 100 parts of flour are used in a straight dough the gassing rate is fairly uniform through 6 or more hours of fermentation. Doughs prepared from previously fermented sponges were less constant in gassing rate,

an appreciable reduction in the rate appearing after the fourth hour of fermentation. When no sugar was included in the formula, the normal-diatase dough showed a substantial reduction in gassing rate during the third hour, and the low diastase dough an hour or more earlier.

When 6% of dry skim-milk was superimposed on the sugar-dough formulas the rate of gas production was stabilized in the instance of both straight dough and sponge dough methods. In the absence of added sugar the reverse effect was registered in sponge doughs.

Increasing the H-ion concentration of a simple flour-water dough to pH = 5.2 by the direct addition of citric acid solution resulted in a progressively increasing mobility as a function of time through at least two hours.

#### Acknowledgments

The authors are pleased to acknowledge the cooperation and assistance afforded by the Pillsbury Flour Mills Company, which supplied materials, laboratory space and the use of special equipment for the prosecution of these researches.



## SOME FACTS CONCERNING VACUUM-OVEN MOISTURE DETERMINATION <sup>1</sup>

J. E. ANDERSON

Kansas Agricultural Experiment Station, Manhattan, Kansas

(Received for publication May 27, 1935)

### Introduction

The results of the moisture determination have only a relative value depending upon the length of drying time and the temperature at which the samples are dried (see Nelson and Hulet, 1920). Because of this fact, procedures have been developed which are adapted to the needs of the laboratory and the demands made on the chemist. In commercial control work, comparative results and speed are essential. Most commercial laboratories desire a rapid method to obtain results which can be duplicated with maximum deviations of 0.20 to 0.50% when small or definite numbers of samples are placed in the oven.

The research laboratory must sacrifice speed to obtain the highest possible degree of accuracy. The usual methods for determining moisture are found to be inadequate for establishing the exact relationship between moisture content and electrical conductivity. The same is true when a correlation is attempted between moisture content and equilibrium relative humidity. Wide variations are usually accounted for by loss of moisture from the sample, improper sampling, and other equally familiar causes. That the procedures in connection with the oven itself may have been at fault has received less attention.

Studies of the factors which cause variation in the results of the moisture determination have brought out some interesting facts. Bailey (1924) shows that 5 hours is insufficient time to completely dry samples in the vacuum oven. The method of estimating the amount of sample and weighing in a closed dish was developed and made a part of the "Methods of Analysis of the Association of Official Agricultural Chemists" in 1926. The placing of the sample dish in the oven with the lid on loosely was made a part of the official procedure in 1928. Flohill (1931) emphasizes the amount of moisture lost in grinding samples when ordinary procedures are followed. Cook *et al.* (1934) present data which led to the adoption of a two-stage drying procedure. In the first stage the samples were dried and then ground

<sup>1</sup> Contribution No. 48, Department of Milling Industry.

under constant conditions of temperature and humidity. In the second stage the samples were dried in an oil-jacketed vacuum oven for 16 hours under pressures of 25 mm. or less at 99 to 100° C.

Variations obtained when the dishes are not covered are small when 2 to 4 samples are placed in the oven at one time. Larger variations are found when 36 to 40 samples are included in one charge.

It was observed that, when twelve or more samples of ground wheat were dried in the air-jacketed vacuum oven with the lids left loosely on the moisture dishes, the rate of drying was decreased compared with the rate observed when the dishes were not covered. These results led to the study of the time and the conditions required to dry samples to constant weight in open dishes so as to avoid the longer drying time required when the dishes were closed. Data from these determinations showed that the wide variations obtained could not be explained by any one of the following factors which influence the moisture determination such as, loss of moisture during grinding, uneven oven temperatures, non-uniformity of the sample, and gain or loss of moisture during weighing. In order to establish the amount of variation produced by each of the factors a series of specific experiments were conducted using the air-jacketed vacuum oven. A part of the experimental work is a repetition of the work of other investigators who have used other types of ovens.

### Methods Used in Drying

The oven was heated by a 500 watt intermittent heater. The thermostat located in the back of the air jacket extended vertically from the top of the oven to within  $1\frac{1}{2}$  inches of the heating element in the bottom. This thermostat operates by means of a series of levers connected to rods of different metals which have different coefficients of expansion. The oven was operated at 100° C., measured in the air jacket outside the vacuum chamber. The air which was admitted into the vacuum chamber was dried with calcium chloride and sulfuric acid, 10 to 12 minutes being allowed for the air to reenter the chamber prior to the removal of the samples. The dishes used were round aluminum pans with lids flanged to fit outside the dishes. Calcium oxide was used in the desiccators in which all samples were left for 30 minutes before weighing.

The method of estimating 2 to 3 g. as the size of sample and weighing in closed dishes before drying was used for all oven moisture determinations.

### Factors Investigated

A series of experiments were conducted to establish the amount of variation caused by each of the following factors which influence the

results of the moisture determination. The variables were limited to one factor in each experiment. The factors investigated were:

1. Loss of moisture during the storage of samples or during the period of time which may elapse between sampling and the time of analysis.
2. Loss or gain of moisture during the grinding of the samples.
3. Gain or loss of moisture during weighing.
4. Length of time required for drying.

(This investigation included the temperature at which the samples exist while in the vacuum oven, the time required to heat the sample to the oven temperature, and the effect of evacuation or reducing the air pressure, on the temperature of the sample.)

5. Effect of using steam shelves inside the vacuum chamber.
6. The effect of exposing the dried samples in open dishes to atmospheric air during the transfer from the oven to the desiccator.

#### **Loss of Moisture During the Storage of Samples**

The amount of moisture lost in 48 hours from 2000 g. samples of wheat was determined in samples which contained from 13.50 to 18.00% moisture. These were placed in one gallon glass bottles stoppered with corks which had been dipped in hot paraffin. The bottles were placed in a thermostat controlled to a temperature of 70° F. for 48 hours. The amount of moisture lost in this time was found by determining the difference in the gross weights before and after storage. The calculated percentages of moisture lost ranged from 0.0 to 0.25%. There was little correlation between the amounts of moisture lost and the moisture contents of the samples, although the larger losses occurred from the wheats with moisture contents in the higher range. This simply means that samples stored in ordinary stoppered bottles may lose small amounts of moisture and to prevent moisture loss the bottles must be sealed.

A second series of samples was stored in 8 ounce bottles in which were placed 100 g. samples of each of various different wheats and the required amount of water added to increase the moisture content of each sample to 13.00%. The bottles were closed tightly with aluminum screw caps gasketed with paraffin-coated cork discs and then agitated vigorously until the wheat kernels ceased to cling to the inside of the bottles. The gross weights of the bottles and wheats were determined to plus or minus 0.05 g. immediately after wetting and again after the samples had been stored for 96 hours at 70° F. The differences were found for the weighings immediately after wetting and 96 hours after wetting and the percentages of moisture lost

calculated. All samples stored in screw cap bottles showed losses of moisture which vary from 0.05 to 0.25% which show that moisture losses do occur when stored in this type of bottle.

A third series of wheat samples weighing 45 to 60 g. were wetted to have moisture contents ranging from 13.50 to 17.50%. Larger samples were wetted according to the procedure used in the preceding series of samples and portions from these were rapidly transferred to 4-oz. bottles and stored in screw cap bottles equipped with paraffin coated cork gaskets in the screw caps and previously tared. The weighings were made with the bottles closed and the sample weight determined by difference between the gross weights and the weights of the bottles. The gross weights of the bottles and wheat were determined to the nearest .005 g. immediately after tempering and also after 23 days storage at 70° F.

Table I shows the moisture contents, gross weights of the wheat

TABLE I  
MOISTURE LOSSES FROM WHEAT STORED 23 DAYS IN BOTTLES CLOSED WITH  
ALUMINUM SCREW CAPS GASKETED WITH PARAFFIN COATED  
CORK DISCS

Serial number	Moisture content	Sample weight when stored	Weight lost in 23 days	Moisture lost
	%	Grams	Grams	%
27	13.50	50.415	0.000	0.000
28	14.00	46.330	0.030	0.065
30	15.50	48.840	0.000	0.000
31	16.50	60.080	0.005	0.008
32	17.00	54.290	0.005	0.009
33	17.50	46.920	0.020	0.042
Average				0.021

and bottles used in the third series, the weight lost during 23 days in storage, and the percent loss in moisture calculated by dividing the loss in weight by the weight of the tempered wheat.

Comparison of the weights before and after storage showed that the moisture losses ranged from 0.0 to 0.065%. The moisture losses showed no correlation with the amount of moisture in the wheat. It would be expected that the greatest moisture losses would occur from the samples containing the largest amounts of moisture and the least losses from the samples with the lowest moisture content. The data obtained do not support this supposition. The loss of moisture which did occur was probably due to small leaks in the gaskets and where the gaskets were tight there were no losses. The data did show that the losses through evaporation during storage in tight containers were not great enough to account for all the variations obtained in the

moisture determinations and that there were other factors which needed investigation.

### Losses During Grinding

Ten portions of wheat 40 to 60 g. each were taken from larger samples held in one gallon bottles previously tempered to have moisture contents ranging from 13.50 to 18.00%. In all cases the samples were transferred as rapidly as possible from the one gallon glass bottles to 4-oz. bottles and the bottles closed at once with screw caps having paraffined discs. The samples were then weighed to the nearest 0.005 g. The grinding was done on a burr mill of special construction so equipped that the sample before grinding is held in an inclosed compartment and the ground material also drops into an inclosed compartment. There is very little heating of the burrs in this mill. This arrangement reduces evaporation during grinding to a minimum. The ground material was returned to the 4-oz. bottle as soon after grinding as possible, and the bottle closed and weighed to .005 g. This gave the necessary data to calculate the losses due to grinding. The samples were ground in order of increasing amounts of moisture.

One series of samples was ground 48 hours after wetting. The data for these are given in Table II. Another series was ground 23 days after wetting. The data for these are given in Table III.

TABLE II  
LOSSES IN WEIGHT FROM WHEAT SAMPLES DURING GRINDING—  
48 HOURS AFTER WETTING

Serial number	Calculated moisture content	Sample weight before grinding	Weight lost in grinding	Percent loss in weight
	%	Grams	Grams	
34	13.50	57.66	0.05	0.08
35	14.00	41.37	0.10	0.24
36	14.50	48.71	0.00	0.00
37	15.00	49.86	0.15	0.30
38	15.50	67.56	0.00	0.00
39	16.00	50.95	0.15	0.29
40	16.50	58.49	0.05	0.08
41	17.00	56.37	0.05	0.09
42	17.50	57.92	0.00	0.00
43	18.00	48.79	0.00	0.00
Average				0.108

In all cases the samples were transferred as rapidly as possible from the one gallon glass bottles to the 4-oz. bottles. The samples were weighed in the closed bottles, placed in the mill above the burrs, and the compartment closed. As soon as the samples had passed through

the burrs the sample was returned to the original bottle and the cap screwed on tightly. The losses from the wheat samples during grinding were determined by weighing the samples to the nearest 0.005 g. before and after grinding. The ten samples were ground in the order of numbering, the lowest number first and the highest number last.

TABLE III  
LOSSES IN WEIGHT FROM WHEAT SAMPLES DURING GRINDING—  
23 DAYS AFTER WETTING

Serial number	Calculated moisture content	Sample weight	Weight lost in grinding	Percent loss in weight
	%	Grams	Grams	
44	13.5	50.41	0.05	0.10
45	14.0	46.33	0.05	0.11
46	14.5	66.60	0.11	0.16
47	15.0	59.59	0.10	0.17
48	15.5	48.84	0.13	0.27
49	16.0	55.45	0.21	0.38
50	16.5	60.08	0.09	0.15
51	17.0	54.29	0.05	0.09
52	17.5	46.92	—	—
53	18.0	44.00	0.14	0.32
Average				0.19

No attempt was made to control the humidity of the room in which the samples were ground. The grinding was done under conditions which ordinarily occur and the burrs were adjusted to grind as fine as possible. No determination of particle size was made.

Tables II and III show the weights of the wheat samples, the loss in weight of the different samples, and the % loss calculated by dividing the loss in weight by the sample weight before grinding. The losses which range from 0.0 to 0.38% are part mechanical and part moisture, but even if the combined losses in the sample weight during grinding were considered to be all moisture, the losses are not sufficient to account for all the variations often obtained in moisture determinations. The slightly larger average loss from the samples in the second series (Table III), indicated a greater amount of evaporation. When samples containing above 13.00% moisture are ground, the bran does not pulverize but remains in flakes. This increased the difficulty of securing representative sub-samples in addition to increased losses of moisture as shown by other investigators.

#### Grinding Procedure with High Moisture Samples

Because of the danger of moisture losses in samples containing more than 13.00% moisture, they should be partially dried before



they are ground. The two-stage method of determining moisture in which the samples are dried to equilibrium with constant relative humidities before grinding is far superior to the procedure of grinding samples which are not at equilibrium.

Grinding the partially dried samples under conditions of temperature and relative humidity with which the samples are at equilibrium greatly decreases the differences of vapor pressure of the moisture in the air and of the moisture in the samples. Equilibrium relative humidity measurements (see Swanson and Anderson, 1935) indicate that the vapor pressure of the moisture in mill stocks is greater than that in whole wheat from which the stocks are ground even when the stocks and wheat contain equal percentages of moisture.

This shows that equilibrium between the moisture in the wheat and atmospheric moisture is changed as soon as the wheat kernels are ground. For this reason some evaporation occurs as soon as the wheat is ground due to the greater vapor pressure of the moisture in the ground material. Under conditions of increased temperatures such as that produced by even the small amount of heating of the burrs in grinding the samples, relative humidity builds up rapidly over the ground stock due to rapid evaporation of moisture from the sample. The moisture which evaporates during grinding is the amount required to increase the humidity of the surrounding air to equilibrium with the moisture in the ground material. This amount is limited by the volume of air and vapor which surrounds the sample or is enclosed inside the burr housing and the moisture which diffuses out into the surrounding atmosphere. The burr housing contained only a small amount of tightly enclosed air space and hence the losses of moisture from the partially dried samples are reduced to a minimum unless excessive heating occurs from grinding a large number of samples consecutively. Rapid transfer of the samples to tight containers with minimum exposure to the atmosphere before weighing is essential. Some vapor may condense on the inside of the bottles but reabsorption will take place after the bottle and sample reach the same temperature. A thorough mixing of the sample before weighing is necessary when this has occurred.

#### **Length of Drying Time Required**

Cook *et al.* (1934) have shown that 16 hours are required for drying in the oil-jacketed vacuum oven. In order to determine the time required to dry wheat meal to constant weight in the air-jacketed vacuum oven, a series of samples were dried for varying periods of time ranging from 1 to 12 hours. The amount of moisture removed during the last 2 hours of drying was small, ranging from 0.03 to 0.05%. This in-

dicated that appreciable amounts of moisture were being removed from the sample. Another series of flour samples were dried for 18 hours, 36 hours, and 54 hours respectively, to determine if these samples would attain constant weight, and the length of time required. During the third 18-hour period of drying the samples showed a loss of about 0.05% moisture, with the oven operating at 100° C. as shown by the thermometer in the air jacket outside the vacuum chamber. The temperature of the samples was probably much lower as indicated by the slowness in drying. The flour samples in this experiment were not brown after 54 hours of drying, but had a pronounced odor. Probably the prolonged heating caused some decomposition. Investigations by Nelson and Hulet (1920) have shown that no serious decomposition occurs when flour is dried at temperatures of about 130° C.

#### Temperature Conditions in the Oven

This experiment was conducted to determine the time required to heat the samples to oven temperature and the effect of this on the rate of drying. To do this 9 previously dried flour samples were placed on each of the 4 shelves of the vacuum chamber, making a total of 36 samples. The lids were removed and placed underneath the moisture dishes in the vacuum chamber. A thermocouple was inserted in the center of the flour in the dish which occupied the center position of the third shelf from the top. Care was taken to have the couple in contact with the previously dried flour, and not in contact with the metal dish. The thermocouple was connected with a galvanometer outside the oven and the temperature of the sample recorded at regular intervals.

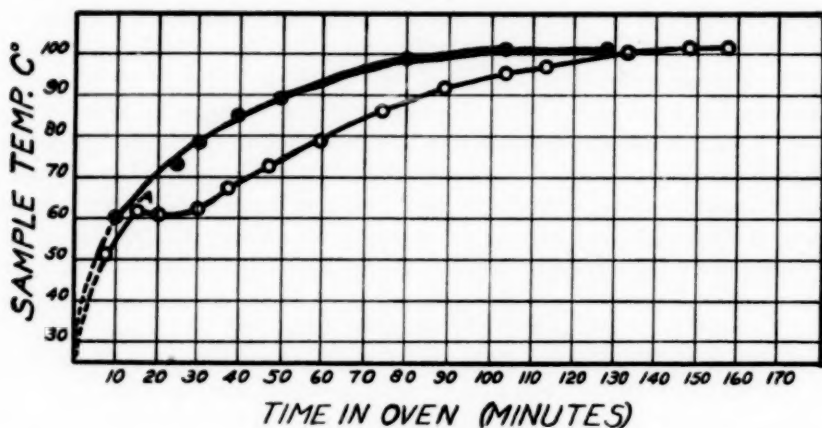


Figure 1.

The upper graph in Figure 1 (solid dots) shows the time temperature relationship for samples from which no moisture is evaporating. A

certain amount of heat is required to increase the temperature due to the specific heat of the material. There were approximately 12 g. of aluminum in each moisture dish and 2 g. of the dry flour. The specific heat of aluminum is approximately 0.2 calorie per gram. The specific heat of dry flour is assumed to be the same as for wheat, or about 0.4 calorie per gram. Hence, 3.2 calories are required for each aluminum dish and dry sample to raise the temperature 1.0° C. Seventy-five times 3.2 calories or 240 calories are required to raise the temperature of each sample to oven temperature.

Air-dry samples usually lose from 0.2 to 0.3 g. of water. Vaporization of water requires 540 calories per gram. From this it is seen that each sample would require 108 to 162 calories of heat to evaporate the moisture. Accordingly, the energy requirements for heating the sample to oven temperature are about twice as great as for the removal of moisture neglecting energy requirements other than that of water vaporization. In the formula  $H = KAT \frac{t_1 - t_2}{d}$ ,  $H$  = calories of heat conducted,  $K$  = conductivity coefficient,  $A$  = the area over which the conduction is occurring,  $T$  = the time in seconds,  $t_1$  = the higher temperature or the temperature outside the vacuum chamber,  $t_2$  = the temperature of the material being heated or the sample, and  $d$  = the distance traversed by the heat.

From this formula it follows that as the temperature of the sample approaches the temperature of the oven the rate of heat conduction will decrease because the difference between  $t_1$  and  $t_2$  will decrease. It is also observed that the cross section of the area through which the heat is being conducted affects directly the amount of heat conducted. This factor is limited by the thickness of the metal shelves and by the area of the shelf which is in contact with the metal sample dish. The heat conductivity of the metal (brass) in the vacuum chamber is approximately 3600 times as great as that for air. The rarified atmosphere inside the vacuum chamber does not act as a conductor but as an insulator instead, and, hence, most of the heat must be conducted to the samples through the thin metal shelves. When these factors are considered it is not surprising that over 1½ hours are required to heat previously dried samples to the temperature of the oven as shown by the graph in Figure 1. Samples from which moisture is evaporating would require still more time. With the slow rate of heat conduction from outside the vacuum chamber to the sample inside, it is apparent why the samples show moisture losses after 36 to 54 hours of drying. The vacuum oven utilizes the reduction of pressure to increase the rate of evaporation. The lower graph in Figure 1 (circles) shows the effect of vacuum on the rate of evaporation and the energy requirements of

moist samples. At point "A" the vacuum was increased from 15 to 20 inches of mercury. The temperature of the sample showed no further increase for a period of 15 minutes. The heat conducted to the sample was consumed in the vaporization of water and none was left for increasing the temperature.

### Steam Shelves Inside the Vacuum Chamber

To overcome the slow conduction of heat from the outside of the vacuum chamber to the samples inside, a set of hollow shelves were constructed and used as a steam radiator inside the vacuum chamber. The individual shelves were constructed from  $\frac{1}{16}$  inch brass plates. The finished shelves were 7 inches square by  $\frac{1}{2}$  inch thick and reenforced at four points, half way from the outer edges to the center and at the outer edges along the seams. The steam inlets and outlets were put at the two corners farthest back in the oven, the inlet on the top side and the outlet on the lower side and at the opposite back corner. The outlet from the top shelf connected with the inlet for steam into the next shelf below and the outlet from the second shelf with the inlet into the third shelf, and so on for the fourth and fifth shelves. In this way all five of the shelves were connected in series. The steam inlet of the top shelf was connected to the steam line from the boiler and the outlet of the fifth shelf connected to the return line to the boiler. The pipes were brought in through packing caps installed in the back side of the vacuum chamber, one near the top for the steam pipe and one near the bottom and on the opposite side for the condensate pipe. The shelves were fitted with baffles to insure circulation of steam throughout the entire shelf. The distance between the shelves when installed was  $\frac{3}{4}$  inch.

Steam was supplied from a small boiler of about 1 quart capacity and heated by two 600 watt tubular elements which extended the entire length of the boiler. The pressure within the boiler operated a set of switches so arranged that the two heating elements could be operated in parallel for 1200 watts, operated singly for 600 watts, in series to secure 300 watts. The switches shut off all the current when sufficient pressure was generated. When there was no steam pressure in the boiler, the heaters operated on 1200 watts or in parallel. As the pressure built up, the pressure-operated control automatically reduced the amount of heat generated until radiation losses equaled the heat input of the heating elements. Whenever radiation losses exceeded the heat input to the boiler sufficiently to lower the pressure, the control immediately switched the elements to one of the higher heating rates. A change of one-half pound of pressure operated the control to give the entire range of heat capacities.

### Heating Samples with Steam Shelves

The aluminum dishes which contained weighed amounts of flour ranging from 2 to 3 g. were placed on the shelves. The thermocouple was put in place as previously described and the time-temperature relationship was again determined when the samples were heated *in vacuo* with the dishes in direct contact with the steam shelves. The graph in Figure 2 shows that the time required to heat dried samples to

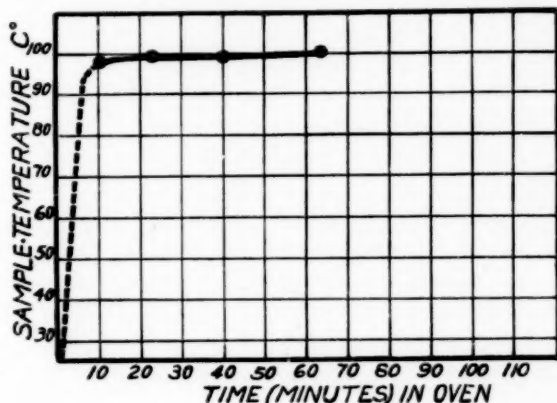


Figure 2.

oven temperature with the steam shelves was 7 to 9 minutes. The steam shelves have the advantage of heating all samples at the same rate, of heating them rapidly with no danger of heating above the temperature maintained by the steam at constant pressure.

### Variation in Moisture Results Dried on Steam Shelves in Open Dishes

An attempt was made to determine the length of time required to dry samples to constant weight or to determine the amount of moisture removed during the different drying periods. To do this, 30 to 40 samples were weighed from a lot of flour of uniform moisture content. The samples were placed in the oven equipped with the steam shelves and dried with the lids off. Triplicate samples were taken out of the oven hourly after drying periods which varied from 1 to 12 hours, cooled 30 minutes in the desiccator and weighed. As shown by the graphs in Figure 3, two series of samples which were heated rapidly to oven temperature and dried uniformly, showed continued losses of moisture for 4 and 5 hours respectively. The conditions inside the desiccator could produce only a uniform change in the weights of the different samples. As previously stated, the air which entered the oven was carefully dried.

The graphs also show that the results varied widely for the different periods of drying after 4 and 5 hours. Theoretically the moisture content should show a slight increase with increased length of drying time,

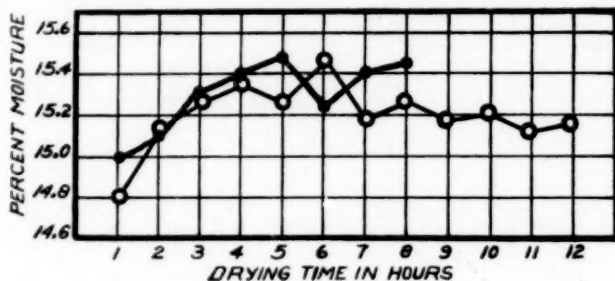


Figure 3.

but as may be seen from the graph a variation of 0.25% is shown which has no correlation with the length of time the samples were dried. This indicates that the exposure of the samples to atmospheric air allowed a variable reabsorption of moisture.

#### Absorption of Moisture while Transferring from Oven to Desiccator

At this point of the investigation all variable factors were eliminated except the length of time the samples were exposed to atmospheric air with the lids off the dishes such as would occur during the transfer from

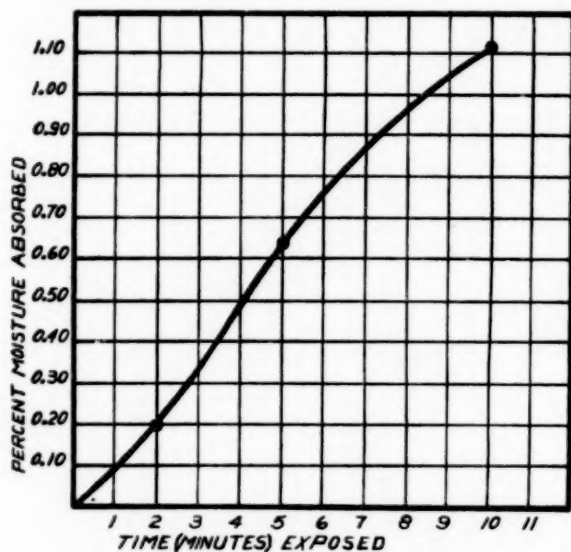


Figure 4.



the oven to the desiccator. To determine the rate at which the dry material will absorb moisture from the air, 9 identical samples of flour were dried for 12 hours in a common type of oven without steam shelves and then removed from the oven at one time by lifting out the shelf which supported the samples. This exposed all the samples to the air uniformly. The time of exposure was varied by allowing triplicate samples to remain exposed to the atmosphere with the lids off for 2 minutes, 5 minutes, and 10 minutes. The graph in Figure 4 shows the amount of moisture reabsorbed by the dried flour. In 10 minutes this amounted to 1.10% moisture when the atmosphere contained 35% relative humidity at 25° C.

### Drying in Closed Dishes

The results obtained from flour and wheat-meal dried with the lids loosely on the dishes in the steam heated vacuum oven for increasing periods of time are shown graphically in Figure 5. The low result

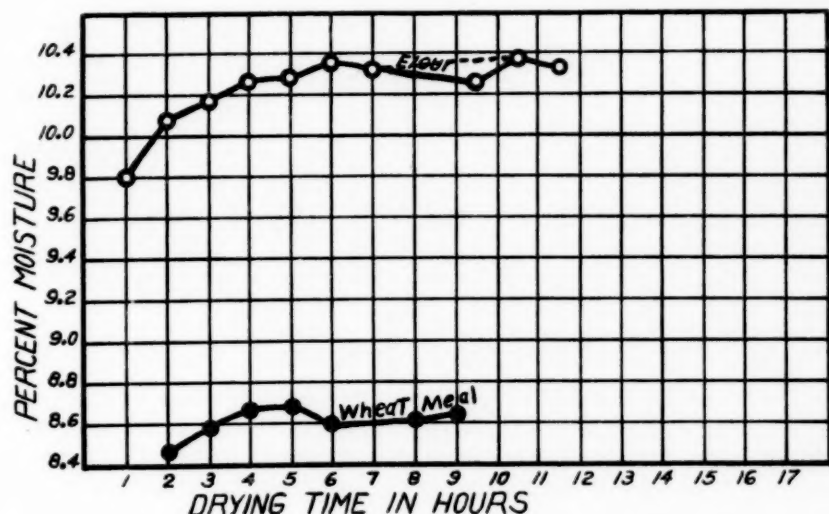


Figure 5.

obtained for flour after 9.5 hours can be explained by the procedure used in drying. Following the seventh hour the dishes containing the samples were left out of the desiccator for 12 hours, returned to the oven and dried for an additional 2.5 hours. No weight was recorded for the samples after 12 hours of exposure to the atmospheric moisture, but it is believed that the moisture reabsorbed during the exposure was not all removed in the additional drying time. Eliminating the moisture results for flour after 9.5 hours, shown in Figure 5, the maximum

variation in percent moisture results for flour after 6.0 hours drying time is 0.04%. The variation in the determinations on wheat-meal after 6 hours drying (Figure 5) amount to less than 0.05%. Comparing the variations shown in Figure 3 and Figure 5, it is seen that the amount of variation is reduced from 0.25% to less than 0.05% when the lids are loosely on the dishes in the oven and the vacuum is released so that the dried air which enters the chamber fills the moisture dishes.

#### **Adaptation of Procedure to the Regular Type of Vacuum Oven**

When samples are dried for 16 to 24 hours in the ordinary type of air-jacketed vacuum oven, the results are in good agreement with those obtained by drying 4 to 6 hours in the steam shelf vacuum oven, the official procedure otherwise being followed. Cook *et al.* (1934) have found that 16 hours are required for drying in the oil-jacketed vacuum oven. In determining the moisture content of tempered wheats, it is advisable to use two stages of drying when the moisture content is above 13%, using 15 to 20 g. of the whole grain in the first stage. A portion of this sample is then used for grinding for the second stage of drying. A procedure similar to this has been used by the Canadian research chemists (Cook *et al.*, 1934) in comparison with other methods for determining moisture.

Time has not permitted the use of the steam shelf oven operated at higher temperatures but an effort is being made to reduce the drying time required for the steam shelf vacuum oven to less than 1 hour. If it is possible to reduce the drying time by increasing the temperature, this type of oven will afford a far more accurate means than the air oven at 130 degrees.

#### **Discussion and Conclusions**

The losses of moisture from samples stored in screw cap bottles were on an average much less than the variation often found in the moisture determinations. Varying exposure of the dried samples to atmospheric air when removing from the oven produced the greatest variation. Next in magnitude was the variation caused by incomplete drying due to the low rate of heat conduction to the samples in the vacuum chamber. No determinations were made concerning the rate of temperature rise in samples at different distances from the chamber walls, but it seems that samples placed near the chamber walls would heat more rapidly than those in the center of the chamber in either the air-jacketed or oil-jacketed vacuum oven.

With rapid heating of samples by the steam shelves as represented in Figure 2 and reducing reabsorption of moisture to a minimum by leaving the lids loosely on the dishes, 4 to 6 hours is sufficient time for

drying, as shown by Figure 5, while 16 to 24 hours are required for drying in the ordinary air-jacketed oven. Drying for 18-hour periods beyond this removed only .05% moisture. Ample drying time should be used to insure uniform results. No harmful effects were found from drying longer than is necessary when a temperature of 100° C. was maintained.

The amount of moisture lost during grinding cannot be definitely established due to the possibility of mechanical losses. Moisture changes during grinding can be reduced either by exposing the samples in an air conditioning apparatus until they reach moisture equilibrium as was done by Cook *et al.* (1934), or by a preliminary drying in the oven. Some such procedure is especially needed if a mill is used in which the burrs heat while grinding.

The reduction of the time from 1½ hours to less than 10 minutes required to heat previously dried samples to oven temperature showed that heat was transferred to the samples about 9 times faster by the steam shelves than by the ordinary type of chamber. The reduction of the drying time was from 16 hours to 4 hours or by about one-fourth and shows that the rate of diffusion of moisture from the samples was the main factor in this reduction of drying time.

Removal of moisture from solid materials ceases when the moisture content is reduced to the point where the vapor pressure of the remaining moisture is zero. Carrier (1921) states that the rate of evaporation is proportional to the ratio of the vapor pressure of atmospheric moisture to the vapor pressure of the moisture in the material. From these facts it is seen that negative evaporation or absorption of moisture by the dried material would take if any moisture existed in the atmosphere as shown in Figure 4. The rate of absorption would increase under conditions of higher relative humidities proportionally to the ratio of the vapor pressure of atmospheric moisture to that held by the solid. Differences in relative humidity from day to day in the same laboratory and in different localities would produce corresponding differences in moisture determinations. For these reasons, drying with the lids off the dishes has been replaced by drying with the lids on.

### Summary

Error due to moisture losses from samples stored in screw cap bottles are less than from other losses.

One and one-half hours are required to heat dried samples to oven temperature in the air-jacketed vacuum oven.

The steam shelf heating device will heat dried samples to oven temperature in less than 10 minutes.

The required drying time is reduced to 4-6 hours when the steam shelf device is used.

These investigations are in agreement with that of others who have shown:

(a) Losses of moisture during grinding may be reduced and a minimum either by conditioning or partially drying the samples previous to grinding.

(b) Keeping the dishes almost closed while in the oven and closing as soon as the oven door is opened eliminates errors due to exposure to the moisture in the air.

#### Literature Cited

Association of Official Agricultural Chemists

1928 Methods of Analysis of the A. O. A. C., Third Edition, p. 165. Published by the Association of Official Agricultural Chemists, Washington, D. C.

Bailey, L. H.

1924 Report of the committee on methods of analysis for the American Association of Cereal Chemists. *Cereal Chem.* 1: 190-202.

Carrier, W. H.

1921 Theory of atmospheric evaporation. *J. Ind. Eng. Chem.* 13: 432.

Cook, W. H., Hopkins, J. W., and Geddes, W. F.

1934 Rapid determination of moisture in grains. I. Comparison of 130° C. air oven and Brown-Duvet methods with vacuum oven method. *Can. J. Research* 11: 264-489.

Flohil, J. T.

1931 Report of the committee on methods of analysis of the American Association of Cereal Chemists. *Cereal Chem.* 8: 306-315.

Lanning, J. H.

1935 A study of temperature changes in a small laboratory oven when drying flour by the 130° C. oven method. *Cereal Chem.* 12: 69-77.

Nelson, O. A., and Hulet, G. G.

1920 The moisture content of cereals. *J. Ind. Eng. Chem.* 12: 40-45.

Swanson, C. O., and Anderson, J. E.

1935 Atmospheric factors in milling. *The Northwestern Miller* 182, No. 2, p. 198.

## THE HARMFUL ACTION OF WHEAT GERM ON THE BAKING QUALITY OF FLOUR AND THE CONSTITUENTS RESPONSIBLE FOR THIS EFFECT

B. SULLIVAN, CLEO NEAR, and GUY H. FOLEY

Russell-Miller Milling Company, Minneapolis, Minnesota

(Received for publication December 21, 1935)

In another paper Sullivan, Near, and Foley (1936) presented evidence that the harmful effect of fresh wheat germ was not due primarily to any lipid constituents, as has been assumed by many previous investigators. Geddes (1930) found that germ added to fifth middlings flour reduced its baking quality as reflected in poorer handling qualities of the dough, and, in the baked loaf, by a decrease in volume, underfermented characteristics, and a coarse, open texture. The addition of bromate, lengthening the fermentation time, or heating the germ before its admixture reduced its harmful effect. Geddes' experiments, as well as those of Rich (1934), indicated to these experimenters that a flour's response to bromate, nitrogen trichloride, and the improvement induced by proper heat treatment, is associated with the presence of germ in the flour.

Geddes suggested that oxidation of the phosphatides is the primary change involved in such improvement. The addition of egg lecithin to the fifth middlings flour caused a marked response in loaf volume on the addition of bromate, which was considered as additional evidence that the phosphatides are involved. The only opposition to this theory is developed in the following two papers: The Eighth Annual Report of the British Flour Millers (1932) presented results to show that neither the fat nor the phosphatides were factors of low-gradeness. Both the ether and alcohol-ether extracts improved the flours to which they were added. Rich (1934) obtained similar results. He found improvement in volume and in the general baking score on adding wheat germ oil (ether extracted), egg yolk, and soy oil to fifth middlings flour. Rich also extracted 5 g. of germ by the MacLean (1918) method (alcohol-ether) and by the Rask and Phelps (1925) method (ammoniacal alcohol). The evaporated extract and the residue were then added to the control middlings flour at the time of mixing the dough. The conclusions from this series of experiments will be discussed later. Rich believes that the similarity of the action of nitrogen trichloride to other oxidizing agents—such as potassium

bromate—indicates that the action is one of oxidation, and that the small quantities necessary for maturation suggest that they affect the colloidal properties of some constituent of the flour. His study does not agree with the hypothesis that the action of these agents on phosphatides is responsible for the improvement by artificial maturation, as has been thought by numerous other chemists.

No suggestion other than the phosphatides has been made regarding the compound responsible for the deleterious effect of wheat germ.

In a former paper (Sullivan, *et al.*, 1936) we have shown that on the natural aging of flours the glycerides and phosphatides hydrolyze to fatty acids, which cause slight harm to the baking quality. Really striking damage is observed, however, when these fatty acids become oxidized.

Sullivan and Near (1933) have shown that the lipids of wheat products—particularly germ—undergo definite changes during aging, depending on the storage conditions. The amount of lipids extractable by alcohol-ether, acetone, and ether alone, and the acidity of the samples show considerable variation upon aging, as well as the phosphorus and nitrogen contents of these extracts. The changes observed were explained as being due to enzymic hydrolysis and were correlated with increasing moisture and acidity of the samples. It became of interest, in view of the preceding results, to see the relative effect of fresh germ and of germ stored at different moisture levels and temperatures on patent flour, and to determine, if possible, what constituent of the germ was responsible for its highly injurious effect on baking quality.

### Experimental

Samples of wheat germ were stored under different conditions of moisture and temperature, some in sealed containers and others in cotton sacks. The change in their effect on the gluten quality of a standard hard spring patent flour was determined on the Farinograph and verified by baking tests.

Farinograph curves were made by adding sufficient water to the flour-germ mixture (10% of the flour weight was replaced by germ in all these experiments) to give a maximum consistency of 580 farinograph units when the total dough weight was 480 grams. Expansion loaves were baked using the following formula: 300 g. of flour at 13.5% moisture, 3½% yeast, 1½% salt, 4% sugar, 2¾% lard, and 0.25% yeast food (Red Star). Absorptions used were determined previously by the Farinograph (Near and Sullivan, 1935) although in the case of the flours containing germ, 2% less absorption than indicated by the Farinograph was employed, because of the poor, sticky dough quality. Mixing was done by a battery of high speed mixers



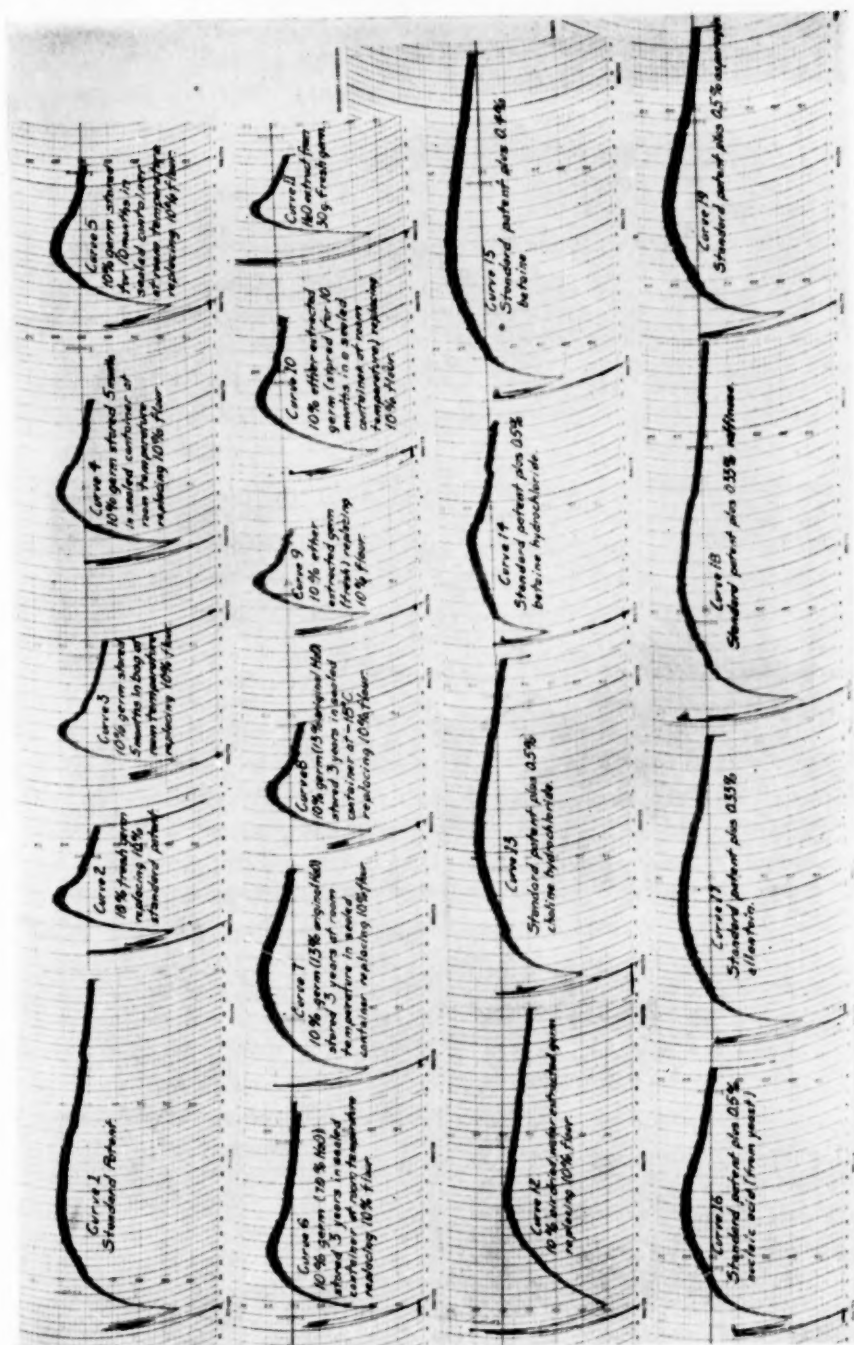


Fig. 1. Farinograph curves illustrated the harmful action of wheat germ and certain organic compounds on the baking quality of flour.

operating on one shaft. Loaves were mechanically molded and proofed to a definite height unless they failed to come up in proof within a reasonable time. The baking data are given in Table I. The loaves were scored for crumb color, texture, and grain, but this information is not given here since it is not necessary for the interpretation of the results. For the sake of brevity, only a few representative farinograms are likewise reproduced.

Curve 1 of Figure 1 illustrates the gluten quality of the patent flour used as a basis for this series of tests. Curve 2 illustrates well the very harmful effect of 10% of fresh wheat germ on gluten quality. The dough was very sticky, short, and hard to handle, as noted in the baking data recorded in Table I. The loaf failed to come up in proof

TABLE I  
BAKING DATA

Sample	Dough quality	Loaf volume 100% basis
Standard—13.00% protein patent flour	Strong, elastic	100
Standard flour and 10% fresh germ	Very poor, soft, short, sticky	61
Standard flour and 10% ether-extracted fresh germ	Very poor, soft, short, sticky	62
Standard flour and 10% of 10 months old germ stored anaerobically at 13.0% H <sub>2</sub> O	Poor, soft	66
Standard flour plus 1% fresh germ fat	Strong, elastic	102
Standard flour plus 1% fat from 10 months old germ stored anaerobically at 13.0% H <sub>2</sub> O	Strong, elastic	97
Standard flour and water extract from 10% fresh germ	Very poor, very soft	72
Standard flour plus 0.2% calcium phytate (from wheat bran)	Strong, elastic	101
Standard flour plus 0.5% nucleic acid (from yeast)	Strong, elastic	99
Standard flour plus 0.5% choline hydrochloride	Strong, elastic	100
Standard flour plus 0.5% betaine hydrochloride	Poor, soft, short	75
Standard flour plus 0.4% betaine (m.p. 194°)	Good, elastic	99.5
Standard flour plus 0.12% hydrochloric acid	Poor, soft	72
Standard flour plus 0.33% arginine carbonate	Strong, elastic	99
Standard flour plus 1% creatine hydrate	Strong, elastic	100
Standard flour plus 0.4% trimethylamine	Poor, dead feeling	77

and gave a volume only 61% of that obtained with the original standard flour.

Two samples of freshly milled germ were stored at room temperature; one in a sealed container with 13% moisture, the other in a cotton sack in which the moisture content of the germ dropped rapidly to 7.0%. Curves 3 and 4 illustrate the effect of these two samples of germ on the gluten quality of the standard flour after five months of

aging. Curve 3 illustrates the effect of the germ stored in a cloth sack. There was no improvement in gluten quality over that experienced with fresh germ. However, the germ stored with high moisture in a sealed container, brought about considerable improvement in gluten quality. This can be seen from curve 4. This improvement is still more marked at the end of ten months, as illustrated by curve 5. In the baking test this decrease in the deleterious action of wheat germ was very noticeable in dough quality, in loaf volume, and in the general appearance of the loaf. This experiment shows the necessity of either a high moisture or an anaerobic condition for the improvement of germ on aging.

Curves 6, 7, and 8 illustrate the effect of three year old wheat germ on the gluten quality of the standard patent flour. The germ used for curve 6 was stored in a sealed container with only 7.0% moisture at room temperature. At the end of three years storage, this sample still contained 7.0% moisture. The germ used for curve 7 was likewise stored in a sealed container at room temperature, but at a moisture content of 13%. At the end of the three-year period the moisture content was 10.7%. The germ used for curve 8 was also stored in a sealed container at 13.0% moisture, but at  $-18^{\circ}$  C. After three years the moisture content had fallen to 11.7%. From an examination of curve 6 only a slight improvement in gluten quality as compared with the effect of fresh germ is apparent. From an examination of curve 7, however, a very marked improvement is apparent. The germ that had been stored at the same moisture content as the germ used in curve 7, but at a low temperature, manifested no significant change as compared to fresh germ as can be seen from curve 8. Higher moisture contents and the higher temperatures, therefore, are both necessary to effect improvement in germ during storage. Even if the moisture content is relatively high, storage at low temperature ( $-18^{\circ}$  C.) inhibits the change.

A control sample of germ containing 7.4% moisture and the same germ treated with X-rays (4 cm. layer in sack for 10 minutes at 42 cm. distance) were stored in sealed containers at room temperature.<sup>1</sup> At the end of a four-year storage period the samples had identical effects on the flour quality curve.

The decided decrease in the harmful effect of germ on the baking quality of a patent flour when the germ is stored with relatively high moisture at room temperature, which is substantiated by baking data as well as farinograph curves, indicates that some change has been effected in the harmful constituent either by enzymic hydrolysis, de-

<sup>1</sup> The authors wish to thank Dr. K. Wilhelm Stenstrom of the University of Minnesota Medical School for his kindness in treating this sample.

composition or rearrangement, and that the end products of the reaction are not as injurious as the original compound.

Since previous work from this laboratory has shown that the lipid fraction of wheat germ changed both in amount and in phosphorus and nitrogen contents on aging, and since others working on the deleterious effect of germ thought that the harmful constituent might be the phosphatides, it was of interest to try to locate and identify the injurious germ compound.

The sample of fresh germ and the sample of germ which had been stored for ten months in a sealed glass jar (see original affects as illustrated by curves 2 and 5) were extracted with cold ether. The action of these germ samples upon gluten quality after ether extraction is illustrated by curves 9 and 10. It is obvious that ether removed none of the harmful material. The ether soluble material which had been extracted from these germ samples was added to the patent flour in the baking test. The data are given in Table I. Although neither fat fraction harmed the dough quality, the fat from the old germ decreased the loaf volume 3% from the standard. The iodine number on the fat from the fresh germ was 125.6 (Rosenmund Kuhnenn method, 1923) and the acid number was 10.2. The fat extracted from the ten months old germ had about the same iodine number—126.3—but the acid number was 70.8, showing the presence of a rather large quantity of free fatty acids. If this sample had been exposed to oxygen—as we endeavored to prove in an earlier paper—the oxidized unsaturated fatty acids would have caused a much greater injury to the dough quality and the loaf volume. Therefore, although germ as a whole during aging is becoming less damaging in its effect on a flour's baking quality, the ether soluble fraction is becoming somewhat more damaging. In any case, the results demonstrated clearly that the ether soluble fraction did not contain the compound we sought.

Other fat solvents, acetone (hot and cold), 95% alcohol-ether, and cold alcohol followed by ether were used for extracting fresh germ, but failed to produce any significant improvement in the germ residue. The only evidence of any amelioration of the germ residue was found when water was present in the solvents, as in the case of 70% ethanol. Rich (1934) found also that the ether extract did not hurt the baking results, and that the ether extracted residue was as detrimental as the unextracted germ. Using MacLean's method for phosphatide extraction with ethyl alcohol and ether, he obtained the same results as when ether alone was employed as the solvent. But in using the Rask and Phelps method—in which water and ammonia are used in addition to 95% ethyl alcohol and ether, so that the total water content of the solvents is about 30%—the bake containing the extract showed

a decrease in loaf volume of 21%, and that containing the germ residue gave a loaf volume which was a check with the control. Rich apparently interpreted both phosphatide extraction methods as similar to the simple ether extraction, although his experimental data shows the two phosphatide extractions gave quite opposite results.

### Water Extraction of Wheat Germ

A charge of 1000 g. of fresh germ was extracted at room temperature with 5000 cc. of distilled water containing a few drops of toluene (toluene in this small amount has no effect on the farinograph curve). The germ was filtered off using cheesecloth and the filtrate centrifuged in a Sharples Super-Centrifuge. The resultant extract contained 9.54% total solids, 0.45% nitrogen, 2% sucrose, and 0.36% ash. An ash analysis gave the following results: 1.36% calcium, 18.98% phosphorus, and 4.13% magnesium. Since 150 cc. of the extract was equivalent to 30 g. of germ, this amount was used in the absorption water for both the baking test and the farinograph curve. Curve 11 and the baking data given in Table I show very definitely that this water extract contains the harmful material of the germ. Curve 11 is fully as weak as curve 2 (10% fresh germ) and the dough quality was as poor as that caused by the admixture of fresh germ. The loaf volume was not as low as with whole germ, but this, no doubt, was due to the fact that a full 100% of flour was used with the water extract, whereas 10% of germ replaced 10% of the flour in the case of the whole fresh germ. Curve 12 shows the action of 10% air-dried, water-extracted germ, and indicates considerable improvement over fresh unextracted germ. In a very few curves such as this one, the exact consistency was not attained. However, since it gave us the information desired the curve was not repeated.

The water extract (150 cc.) was boiled for 5 minutes, the precipitated albumin and protein nucleinates filtered off, and the clear filtrate used in the absorption water for a farinograph curve. The farinograph curve obtained, was identical with curve 11, eliminating the possibility that the deleterious material in germ is enzymatic in nature.

Since the harmful material is water soluble, several water soluble compounds which are known to occur in germ were tried for their behavior in the Farinograph and in the baking test.

Calcium phytate was prepared from wheat bran by the method of R. J. Anderson (Morrow, 1927). It was found to contain 13.63% phosphorus, 16.5% calcium, and 58.37% ash. The analysis indicated that the formula was  $C_6H_9O_{15}P_3Ca_3 \cdot 10 H_2O$ . Andrews and Bailey (1932) reported 1.98% phytin in wheat germ. Therefore, 0.2%



calcium phytate (equivalent to the amount present in approximately 30 grams of germ) was used in the baking test and farinograph procedure. No bad effect was observed. If the harmful material had been phytin, wheat bran which contains 4.99% phytin (Andrews and Bailey, 1932) should have a more harmful effect than germ. Farinograph data shows, however, that bran is much less harmful than germ.

Richardson and Crampton (1886) suggested the presence of raffinose in wheat germ, based on the rotation found after inversion. Shulze and Frankfurt (1893) were the first to isolate raffinose from wheat germ. Colin and Belval (1934) found 4% raffinose in the wheat embryo. Sucrose has been found in wheat germ by many investigators, and occurs in rather large amounts (10 to 20%). The quantity of sucrose (5.2%) reported by Colin and Belval seems to be too low to the authors. Allantoin (0.5%) was found in wheat germ by Richardson and Crampton (1886). Shulze and Frankfurt (1893) isolated choline and betaine from wheat germ. The amount of choline found was smaller than the amount of betaine. Powers and Salway (1913) confirmed the presence of choline, betaine, allantoin, sucrose, and raffinose in wheat germ. The nucleic acids of the embryo have been investigated by Osborne and Harris (1902), and Thomas and Dox (1925).

In view of the occurrence of these various compounds in wheat germ, it was of interest to study their action on a patent flour by means of farinograph curves. The materials were used, in most cases, in approximately the amount of their occurrence in 30 grams of germ. Raffinose, sucrose, allantoin, nucleic acid (from yeast), and choline hydrochloride (Eastman) were all found to be without any significant action on the flour water curve. Asparagin, another compound which was tried, exhibited a slight shortening effect on the dough quality of the standard flour, with a resultant small decrease in loaf volume. Betaine hydrochloride (0.5%) showed a very marked weakening effect on the curve. The dough quality was poor, soft, and short, and very similar to that caused by the water extract of germ. The loaf volume was considerably below the standard. Free betaine,  $C_5H_{11}O_2N$ , was then prepared from an absolute alcohol solution of the hydrochloride by the action of silver oxide, and several subsequent precipitations from absolute alcohol by anhydrous ether, according to the method of Willstätter (1902). It melted with decomposition at  $294^\circ C$ . The free betaine (0.4%) when used for the curve and in the baking test had no appreciable effect. The dough did not feel quite as elastic, but the volume was a close check with the standard. The injurious action of the betaine hydrochloride must have been due to the loosely bound HCl. This was verified in both the Farinograph



and the baking test by using an amount of HCl as calculated from the amount present in 0.5% of betaine hydrochloride, as well as by the employment of free betaine.

Arginine carbonate and creatine hydrate had little effect. Trimethylamine (2 cc. anhydrous), the decomposition product of choline and betaine, had a very damaging action in the baking test but is not the compound responsible for the injurious effect of germ since germ improves on aging and trimethylamine occurs in larger quantities in aged germ.

Guanidine,  $\text{CN}_3\text{H}_5$ , a very strong base, has a decidedly detrimental effect on the flour-water curve and in the baking test. The dough did not become sticky, as with the germ, but felt dead.

Further research on the action of other compounds and the identification of the injurious material will be discussed in another paper.

### Conclusions

Fresh wheat germ has a very deleterious effect on the baking quality of patent flour.

When stored with a relatively high moisture content, and at room temperature in a sealed container, wheat germ loses much of its injurious action, showing that some change has been effected in the harmful constituent either by enzymic hydrolysis or decomposition, and that the by-products of the reaction are not as injurious as the original compound.

Ether extraction of fresh germ does not lessen its bad effect, proving conclusively that the harmful constituent is not ether soluble.

Fat extracted by ether, as well as by other common fat solvents, from fresh germ does not change the baking quality of patent flour. Fat from germ which had been stored in a sealed container at room temperature and with a relatively high moisture developed a high acid number, and the presence of free, unsaturated fatty acids decreased the loaf volume a little.

A water extract of fresh germ contains the harmful constituent as evidenced by both Farinograph and baking tests. The material is apparently not harmed by short heating. Even the heated solution keeps poorly.

The effect of certain water soluble compounds known to be present in the wheat embryo, as well as other compounds whose action we wished to determine, were tried on a standard patent flour using the Farinograph and baking tests. The following substances had little or no effect: calcium phytate (prepared from wheat bran), nucleic acid (from yeast), raffinose, sucrose, allantoin, choline hydrochloride, betaine, asparagin, arginine carbonate, creatine hydrate.

Trimethylamine had a very damaging action in the baking test, giving a dead feeling dough. However, trimethylamine is not the compound responsible for the detrimental action of the germ. Guanidine also had a very detrimental action.

Further work on this subject will be reported in another paper.

#### Literature Cited

- Andrews, John S., and Bailey, C. H.  
1932 Distribution of organic phosphorus in wheat. *J. Ind. Eng. Chem.* **24**: 80-82.
- Colin, H., and Belval, H.  
1934 Le raffinose dans les grains de céréales. *Bull. Soc. Chim. Biol.* **16**: 424-427.
- Geddes, W. F.  
1930 Chemical and physico-chemical changes in wheat and wheat products induced by elevated temperatures. III. The influence of germ constituents on baking quality and their relation to improvement in flour induced by heat and chemical improvers. *Can. J. Research* **2**: 195-213.
- MacLean, H.  
1918 Lecithin and Allied Substances. Longmans, Green & Company, London.
- Morrow, C. A.  
1927 Biochemical Laboratory Methods. John Wiley and Sons, New York, New York, pp. 242-244.
- Near, Cleo, and Sullivan, B.  
1935 The use of the farinograph as an accurate measure of absorption. *Cereal Chem.* **12**: 527-531.
- Osborne, T. B., and Harris, I. F.  
1902 Die Nucleinsäure des Weizenembryos. *Z. physiol. Chem.* **36**: 85-133.
- Powers, Frederick B., and Salway, A. H.  
1913 Chemical examination of wheat germ. *Pharm. J.* **91**: 117-120.
- Rask, O. S., and Phelps, I. K.  
1925 Extraction and estimation of lipoids of cereal products. *J. Ind. Eng. Chem.* **17**: 187-190.
- Research Association of British Flour Millers  
1932 Research studies on low-gradeness of wheat flour (abstract of report in Canadian Milling and Grain Journal, March, 1932, p. 9).
- Rich, C. E.  
1934 The chemical and physico-chemical changes induced in wheat flour by artificial maturing agents. *Cereal Chem.* **11**: 201-227.
- Richardson, Clifford, and Crampton, C. A.  
1886 Vorläufige Mittheilung über die Zusammensetzung des Weizenkeimes und über die Anwesenheit von einer neuen Zuckerart und von Allantoin. *Ber.* **19**: 1180-1181.
- Rosenmund, K. W., and Kuhnenn, W.  
1923 Eine neue Methode zur Iodzahlbestimmung in Fetten und Ölen unter Verwendung von Pyridinsulfat dibromide. *Z. Nahrs u. Genussm.* **46**: 154-159.
- Schulze, E., and Frankfurt, S.  
1893 Über das Vorkommen von Betain und Cholin in Malzkeimen und in Keim des Weizenkorns. *Ber.* **26**: 2151-2155.
- Sullivan, B., and Near, Cleo  
1933 Change of crude lipides of wheat on storage. *J. Ind. Eng. Chem.* **25**: 100-109.
- and Foley, G. H.  
1936 The role of the lipids in relation to flour quality. *Cereal Chem.* **13**: 318-331.
- Thomas, Adrian, and Dox, A. W.  
1925 Untersuchungen über die Natriumsalze der Nucleinsäure aus Weizenkeimen. *Z. physiol. Chem.* **142**: 1-13.
- Willstätter, Richard  
1902 Ueber Betaïne. *Ber.* **35**: 584-620.

## THE CAROTENE CONTENT OF WHEAT VARIETIES IN THE PACIFIC NORTHWEST

C. C. FIFIELD,<sup>1</sup> S. R. SNIDER,<sup>1</sup> HARLAND STEVENS,<sup>1</sup>  
and RAY WEAVER<sup>2</sup>

United States Department of Agriculture, Washington, D. C.

(Read at the Annual Meeting, June 1935)

It is the desire of the agronomist to produce strains of wheat that shall combine characters such as high yield, stiff straw, and resistance to disease, drought, and shattering; in other words, varieties which give greatest returns to the farmer. The commercial processor or miller is especially concerned with the quality and quantity of flour that he can obtain from the grain. The baker, on the other hand, demands a flour meeting certain standards with respect to ash, protein, viscosity, *etc.* For many years the public rightly or wrongly has demanded flour and bread meeting certain standards with respect to color. This is particularly true with respect to flour to be used for cake and similar baking products. Since a considerable proportion of the wheat from some sections of the Pacific Northwest which goes into domestic consumption is used for cake and other pastry purposes, it has seemed desirable to give considerable attention to color in attempting to evaluate the quality of wheat and flour from this region. Color of flour may be a result of many factors divided roughly into four groups: (1) Mechanical difficulties in properly cleaning the wheat free from impurities previous to milling; (2) low test weight or damage either by frost or during unfavorable storage conditions previous to milling; (3) environment under which the grain was produced; and (4) variety.

The present studies deal only with differences in carotene content due to variety and environment. Samples of both wheat and flour of Marquis, Baart, Federation, Onas, Irwin Dicklow, and White Federation grown at Logan, Utah, and Aberdeen, Idaho, in 1933 and 1934, and at Bozeman, Mont., in 1933 were analyzed for carotene and protein content. The carotene content of wheat and flour was correlated with color of the bread crumb. Carotene concentration in the various milled fractions and the effect of bleaching agents on flour from the different varieties were also determined.

<sup>1</sup> Division of Cereal Crops and Diseases, Bureau of Plant Industry.

<sup>2</sup> Grain Division, Bureau of Agricultural Economics.

### Methods

Determination of carotene content of flour and grain has been limited in the past to gasoline extracts or the Pekar Test. Values thus obtained have been used to study the correlation of wheat or flour with crumb colors of the finished loaf of bread. In the present study, carotene pigments, expressed as parts per million, were determined by the method outlined by Geddes, Binnington, and Whiteside (1934). Their method involved extracting 20 g. of wheat meal or flour with 100 cc. of naphtha-alcohol, recommended by Ferrari (1933), consisting of seven parts of absolute ethyl alcohol and 93 parts of petroleum distillate. Since no centrifuge was available the color extracts were filtered through No. 5 Whatman filter paper into large test tubes and allowed to stand two days after which the clear solution was siphoned off with a capillary bore siphon. The solutions thus measured were found free from flour particles when analyzed by the Duboscq colorimeter in combination with the mercury arc lamp as a light source.

Analyses of the flour were based on a first patent of 60% extraction and a second patent of 40% extraction. The samples were milled on an Allis Chalmers experimental mill. The customary chemical analyses of ash, protein, and moisture were made and the first patent flour was baked into bread. The A.A.C.C. baking test was employed, except that the sugar was increased from 2-1/2% to 5%, the yeast reduced from 3% to 2%, and the fermentation period shortened from 3 hours to 2-1/2 hours.

### Experimental Results

The carotene content of the whole wheat for the six varieties grown at Logan, Aberdeen, and Bozeman in 1933 and 1934 is shown in Table I. It will be noted that the carotene values range from 1.32 to 3.86

TABLE I

CAROTENE CONTENT OF 6 WHEAT VARIETIES GROWN AT BOZEMAN, MONT., IN 1933, AND AT LOGAN, UTAH, AND ABERDEEN, IDAHO, IN 1933 AND 1934

Variety	Carotene content (p.p.m.) <sup>1</sup>					Average
	Bozeman, 1933	Logan, 1933	Logan, 1934	Aberdeen, 1933	Aberdeen, 1934	
Irwin Dicklow	2.03	1.32	1.83	1.58	1.94	1.74
Baart	1.88	1.45	2.06	1.32	2.51	1.84
Marquis	1.86	1.38	2.62	2.01	1.90	1.95
White Federation	2.26	2.06	2.15	2.24	2.80	2.30
Onas	2.90	2.24	2.87	2.28	3.50	2.76
Federation	3.01	3.01	2.96	2.69	3.86	3.15
Average	2.32	1.91	2.42	2.02	2.75	

<sup>1</sup> Parts per million.

parts per million for the individual samples. On the average, Federation has the highest concentration and Onas, White Federation, Marquis, Baart, and Irwin Dicklow have lesser amounts in the order named. It is pertinent to note that, in general, varieties having a high carotene content at one location are high elsewhere, indicating a varietal characteristic. Federation has the highest and Onas the second highest concentration at each station. White Federation also ranks third at each station except one.

There is also considerable variation in carotene content, depending on the location and season. Different growing conditions apparently affect the carotene content, but no details as to the specific causes are known. The highest average for all varieties was secured at Aberdeen in 1934; the other stations and seasons are in the following order: Logan, 1934; Bozeman, 1933; Aberdeen, 1933; and Logan, 1933. The grain from the 1933 crop was stored for 16 months, whereas the 1934 crop material was stored four months only before it was milled and analyzed. If oxidation affects the content of the grain as appears entirely possible, the lower carotene content of the grain grown in 1933 may have been due to the longer period of storage. It is well known that oxidation takes place during the storage of flour, resulting in a loss of coloring material, and this same phenomenon very likely occurs during storage of wheat.

Coleman and Christie (1926) studied the gasoline color values of straight grade flours from several classes of wheat and obtained wide variations among the samples of each class. A sample of white wheat gave the highest value and one of soft red winter gave the lowest value. Correlation studies on 194 durum wheat flours showed that there was no relationship between the gasoline color value and the protein content. Smith and Clark (1933), working with durum wheats, also found no marked relationship between gasoline color values and protein content.

Whiteside (1931) found that flour from hard red spring wheat generally has a higher carotene content than the wheat from which it was milled. Apparently the endosperm contains more of the carotenoid pigments than does the remainder of the wheat kernel. He also found a significant relationship between the color of the wheat and the color of the patent flour as shown by the correlation coefficient of  $0.958 \pm 0.0185$ .

Carotene content and protein content from the first and second patent flours and the carotene content and weight per bushel of the wheat obtained in the present study are arranged in Table II according to variety and in Table III according to station and year. No relationship was found between carotene and protein content as evidenced

by the correlation coefficient of  $-0.296 \pm 0.251$ . The correlation coefficient of  $0.672 \pm 0.040$  was obtained between carotene values of the wheat and the weighted average of the values obtained for the first and second patent flours. Contrary to Whiteside's results, the flour contained less pigment than the whole wheat.

TABLE II

MEAN CAROTENE CONTENT AND WEIGHT PER BUSHEL OF WHEAT AND THE MEAN CAROTENE AND PROTEIN CONTENT OF THE 1ST AND 2ND PATENT FLOURS OF EACH SIX VARIETIES OF WHEAT FOR THE 5 STATION YEARS

Variety	Weight per bushel	Protein content		Carotene content (p.p.m.)		
		1st patent	2nd patent	Wheat	1st patent	2nd patent
	<i>lbs.</i>	%	%			
Irwin Dicklow	58.7	7.33	8.23	1.74	.81	1.10
Marquis	61.5	10.49	10.32	1.95	1.15	1.42
Baart	61.7	9.04	10.45	1.84	1.13	1.48
White Federation	60.8	9.16	8.77	2.30	1.34	1.54
Onas	59.1	7.51	8.52	2.76	1.53	2.29
Federation	60.0	7.58	8.68	3.15	2.07	2.73
Average	60.3	8.58	9.15	2.28	1.34	1.75

TABLE III

MEAN CAROTENE CONTENT AND WEIGHT PER BUSHEL OF WHEAT AND MEAN CAROTENE AND PROTEIN CONTENT OF THE 1ST AND 2ND PATENT FLOURS FOR EACH OF 5 STATION YEARS FOR 6 VARIETIES OF WHEAT

Location and crop year	Weight per bushel	Protein content		Carotene content (p.p.m.)		
		1st patent	2nd patent	Wheat	1st patent	2nd patent
	<i>lbs.</i>	%	%			
Logan, 1933	60.7	9.25	9.71	1.91	1.03	1.49
Logan, 1934	59.4	7.48	8.03	2.42	1.33	1.63
Aberdeen, 1933	60.9	9.14	9.57	2.02	1.84	1.99
Aberdeen, 1934	60.7	8.19	8.86	2.75	1.43	1.90
Bozeman, 1933	59.8	8.87	9.60	2.32	1.07	1.76
Average	60.3	8.58	9.15	2.28	1.34	1.75

Ferrari and Bailey (1929a), reporting on the concentration of carotene in the various flour streams that go into the straight grade flour from the Minnesota State Testing Mill, indicated that the yellow coloring matter was well distributed in the various milled fractions. The bran, shorts, 1st break, and duster flour contained high concentrations of carotene in comparison with the other streams. They also determined the carotene content of various products from the



same sample of wheat. The results, expressed as parts per million, were as follows: Bran 2.88, shorts 3.40, red dog 2.85, and straight grade flour 2.43.

In the present study, the carotene content of the bran, middlings, and first patent and second patent of the six varieties of wheat grown at Aberdeen, Idaho, in 1933, was determined. The results are shown in Table IV. The bran was ground to the fineness of

TABLE IV  
CAROTENE CONTENT OF WHEAT AND ITS VARIOUS MILLED FRACTIONS. WHEAT  
VARIETIES GROWN AT ABERDEEN, IDAHO, 1933

Variety	Carotene content (p.p.m.)					
	Wheat	Bran	Middlings	1st clear	2nd patent	1st patent
Baart	1.32	2.58	2.58	1.15	1.68	1.43
Irwin Dicklow	1.58	2.35	2.24	1.00	1.52	1.41
Marquis	2.01	3.48	2.35	1.27	1.88	1.41
White Federation	2.24	3.59	2.80	1.45	1.49	1.54
Onas	2.28	4.04	3.48	2.03	2.56	2.58
Federation	2.69	3.93	4.27	2.56	2.82	2.69
Average	2.02	3.33	2.95	1.57	1.99	1.84

the middlings before color analyses were made. The data indicate that the greatest concentration of carotene is in the bran and a lesser amount in the middlings. Two exceptions to this are Baart, in which the values are equal for both fractions, and Federation, in which the carotene content of the middlings is greater than that of the bran. There appears to be a greater concentration of carotene in the second patent flour than in the first patent and less in the first clear than in either of the patents. It appears, therefore, that the general inferiority of the first clear flour with respect to color is due not to the carotene it contains but to some other factor, probably dirt and other foreign matter.

Carotene content of wheat and flour is of interest only to the extent that the yellowness is noticeable in the finished loaf of bread or cake. With this in mind, the first patent flours milled from the 30 samples were baked into bread. The crumb colors were scored, and these were correlated with the carotene content of the wheat. The correlation coefficient was found to be  $+0.4889 \pm 0.0629$ . Composite flour samples of each variety made up from the 1st patent flours from 3 stations were bleached, 4 g. of Agene per barrel and 1 lb. of Novadel per 35 barrels being used. The experimental bleacher manufactured by the Wallace and Tiernan Company was used for this purpose. Details for the use of this apparatus have been outlined by Ferrari and Bailey (1929b) and need no further explanation here.

The bleached samples of flour were permitted to age six days before determining the carotene content. Carotene in the bleached and unbleached flour from the six varieties and the loss of carotene, in p.p.m. and percent, due to bleaching are shown in Table V. It is

TABLE V

CAROTENE CONTENT OF UNBLEACHED AND BLEACHED FIRST PATENT FLOUR OF 6 VARIETIES OF WHEAT. SAMPLES WERE COMPOSITE OF FIRST PATENT FLOUR FROM GRAIN GROWN AT 3 LOCATIONS

Variety	Carotene content (p.p.m.)		Loss in carotene	
	Unbleached	Bleached	P.p.m.	Per cent
Irwin Dicklow	1.02	.50	.52	51.0
Marquis	1.34	.46	.88	66.0
Baart	1.36	.50	.86	63.0
White Federation	1.43	.69	.74	52.0
Onas	2.05	1.17	.88	43.0
Federation	2.33	1.15	1.18	51.0

evident that bleaching removed a considerable part of the carotene pigment. It is of interest to note that Federation and Onas after treatment contained as much pigment as the untreated Irwin Dicklow. Heavier bleaching would no doubt remove additional coloring material from these two varieties resulting in a white flour, without showing signs of over-treatment. Marquis and Baart responded to the action of this bleaching treatment with a loss of more than 60% of their color; Federation and Irwin Dicklow approximately 50% loss; and Onas only 43% loss.

### Summary

The carotene content of 6 varieties of wheat grown at Aberdeen, Idaho, and Logan, Utah, in 1933 and 1934, and at Bozeman, Mont., in 1933, was determined.

The effect of inherent varietal characteristics was apparent in that the varieties Federation and Onas, which produced high carotene values at one station, were also high at other stations. Conversely, Irwin Dicklow, Baart, and Marquis were low at all stations.

It was found that environment has an important effect on the carotene content of the wheat, as shown by the different values on identical varieties produced at three locations and at the same location in different years.

There is no indication of a correlation between carotene and protein content of the grain.

A definite relationship was found between carotene in wheat and

carotene in the flour milled from it. Crumb color of bread was also significantly correlated with carotene content of the wheat.

Measurements made on the various milled fractions from the same sample of grain show the bran to be the highest in carotene content with decreasing values in the middlings, 2nd patent, 1st clear, and 1st patent.

Bleaching studies show that the varieties Federation and Onas require additional treatment to remove the high percentage of coloring matter they contain. Carotene determinations on the bleached flours showed the loss in carotene as follows: Marquis, 66%; Baart, 63%; White Federation, 52%; Irwin Dicklow, 51%; Federation, 51%; and Onas, 43%. More carotene was left in flour milled from the Federation and Onas after bleaching than was in the Irwin Dicklow before bleaching.

#### Literature Cited

- Coleman, D. A., and Christie, A.  
1926 The gasoline color value of several classes of wheat. *Cereal Chem.* **3**: 188-193.
- Ferrari, C. G.  
1933 Spectrophotometric determination of the carotenoid pigment content of wheat flour. *Cereal Chem.* **10**: 277-286.
- , and Bailey, C. H.  
1929a The determination of carotene in flour. *Cereal Chem.* **6**: 347-371.  
1929b Effect of storage and of various bleaching agents on the carotene concentration of flour. *Cereal Chem.* **6**: 457-482.
- Geddes, W. F., Binnington, D. S., and Whiteside, A. G. O.  
1934 A simplified method for the determination of carotene in flour extracts. *Cereal Chem.* **11**: 1-24.
- Smith, G. S., and Clark, J. Allen  
1933 Inheritance of stem rust reaction and correlation of characters in Pentad, Nodak, and Akrona durum wheat crosses. U. S. Dept. Agr. Tech. Bull. 385.
- Whiteside, A. G. O.  
1931 A study of the carotenoid pigments of wheat and flour with special reference to wheat varieties. Dom. of Can., Dept. Agr. Bull. No. 154, New Series.

## PRESIDENTIAL ADDRESS

WASHINGTON PLATT

The Borden Company, Research Division, Syracuse, New York

(Read at the Annual Meeting, Dallas, Texas, June 1, 1936)

It is the proud and truthful boast of the American Association of Cereal Chemists that it is not a one man association. On the contrary a very large proportion of the membership takes part in its multifarious activities and shape them for good or for ill. Therefore, though the Annual Presidential Address is delivered by the President, it is in no sense a report of the activities of the President, but of the Association as a whole.

First of all, a very pleasant part of my duties is to acknowledge the excellent work of the officers, the members of all committees, and the local section officers and committees, also the editors of CEREAL CHEMISTRY.

It is a pleasure to report, then, that due to the efficient efforts of many members in many lines of activity, our Association is in a thriving condition.

### Condition of Our Association

The Membership Committee is to be congratulated upon a net gain of 25 in membership since this time last year, giving us well over 500 members for the first time in our history. Treasurer Mize has exercised his usual care in guarding our finances so that the year shows a small surplus. The Secretary has been most useful and has entirely justified the creation of the separate office. CEREAL CHEMISTRY has had the most successful year in its history with the greatest subscription list, the largest number of pages published, and the greatest financial profit. So much for quantity—the least important phase of our work.

Quality cannot be so easily or surely evaluated yet there is every evidence that quality has improved. The morale and good feeling in our membership was never better. The scientific standing of the Journal was never higher.

Probably no scientific organization has such a large proportion of its membership actively engaged in committee work (105 out of 517). This is a matter of pride and strength. In the committees which con-

tinue from year to year the policy has been to retain a majority of the personnel, so as to obtain continuity of effort; but to make some changes each year so as to introduce some new blood, get some new ideas, and give everybody a chance.

In the appointment of committees there is a tendency to name those whom we know and sometimes to overlook equally good men whom we do not happen to know. Last year the policy was inaugurated of inviting local section chairmen to send in suggestions for the committees from their local membership. This has worked well and is being continued.

The local sections of the A. A. C. C. were started during the presidency of Rowland Clark. The fact that they fulfilled a real want is shown by their rapid growth. A moment's thought will show what a large part these play in the life of the A. A. C. C. The National Association holds but one meeting a year, whereas the local sections average about 6 meetings a year. About a quarter of our membership is able to attend the annual meeting whereas nearly every member can and does attend several local meetings.

We are proud of the fact that the local sections are self-governing and self-supporting. Each works out its own destiny in its own way. At the same time it is natural to expect that the different sections should be able to help each other by an exchange of ideas, speakers, *etc.* Anything which can be done to raise the standard of section meetings is an important contribution to cereal chemistry, because it is to these meetings that most of our members look for cereal chemical contacts.

To assist in this important work a special meeting of local section officers was held at Dallas yesterday.

Having now given a brief factual survey of the year let me indulge in a few opinions.

### Looking Forward

Even in the face of these encouraging signs no one would be foolish enough to feel undue complacency. If much has been done, there is certainly even more to do. There is much to be learned about our science, and many improvements are necessary in our methods. Science should play a larger part in the milling, baking, and allied industries.

Our association is the instrument which must bring about these advances.

To effect the last named step and "to encourage a more general recognition of the chemist and biologist as essential factors in the development of the cereal industries" as our constitution so clearly expresses it, an Interrelations Committee was formed this year for the

first time. Work so far has been largely spent in laying the foundations. We look to real progress in this respect as the years go on.

Looking forward now to possible dark years sometime in the unseen future, I should like to call the attention of the Association to how little can be accomplished by the president during one term of office.

For comparison, let us look at some of our other activities. Unquestionably our most important and substantial undertaking is the publication of CEREAL CHEMISTRY. This is possible only because the editors have a reasonably lengthy tenure of office. In the business of the Association the great bulk of the duties falls upon the Treasurer. The present high state of efficiency could not be reached without the experience which comes of several years in this work.

On the other hand, for the past few years the President has served for one year only. This has worked well under the conditions which now obtain. It is true of the immediate past presidents (and most of all true of the present incumbent) that they could not have spared the time to serve another term.

It is a simple fact, however, that under our system of one general meeting a year the president can accomplish little in the way of personal leadership or in carrying through any one policy which seems to him important.

The present system is best for present fair-weather conditions. However, if the Association should come on evil days, then it would be necessary to elect a good man and keep him in office for two or even three years until conditions were rectified. Suppose, for example, that our Journal, now so thriving, should experience a severe slump. Suppose that our Association should be rent by discord with one faction threatening to withdraw. Then it would be quite important to continue one good man in office until the storm was weathered.

I take the opportunity to say this at the present time because no such clouds are now in sight, because this is *not* a year when the president should be reelected, and because my remarks can, therefore, have no personal reference whatever. They are merely intended to present a condition which the Association should understand and so be prepared to act upon if occasion should require. In the same way no part of our election customs should be considered too rigid, but should be varied as occasion requires.

### **The Profession of Cereal Chemistry**

The Science of Cereal Chemistry has many achievements to its credit and the profession of cereal chemistry is one in which we can all take pride. It has a long and glorious history. Let us take a brief glance at some of the high spots of the past.



Cereal Chemistry may be said to have had its beginnings in 1745 with the announcement by Beccari before the Academy of Bologna of the preparation of wheat gluten. Through the following century progress lagged until Liebig in 1841, von Bibra in 1860, and Ritthausen in 1872 began their efforts to separate and study the individual wheat proteins. This led to the theories of Fleurent in France and of Harry Snyder in Minnesota that the ratio of glaidin to glutenin was a determining factor in flour strength. The epoch-making work of Osborne in Connecticut served geratly to clarify the issue of how many and what kinds of proteins are to be found in wheat, although his simple system has been complicated somewhat by the later researches of Doctors Breese, Jones, Gortner, Blish, and others. At any rate, the studies of the past 40 years have greatly advanced our knowledge of these proteins and their possible rôles in bread production.

At the same time it has become apparent that the properties of these proteins are largely influenced by their environment. The pioneer work of Woods and Hardy in England stimulated great interest in this important phase of the chemistry of flour strength. It has been extensively studied in numerous laboratories, including those at the Universities of Nebraska and Minnesota, and Kansas State College. Working's contributions on the rôle of the phospholipins have suggested an important line of reasoning, particularly as respects the cause of the differences between high and low grade flours. Wo. Ostwald and Lüers in Germany, and Sharp and Gortner in Minnesota were prominent in the study of the viscosity of flour and flour proteins and the relation of that property to flour strength.

In this connection the protein-splitting enzymes or proteases are of significance and the work of Jørgensen in Denmark, Balls and Bailey in the United States, and others has suggested that the activity of these enzymes may be controlled by certain bread-improvers, particularly those which increase the oxidation potential of the system.

Sugars have long been recognized as normal constituents of wheat flour, but during the past five crop seasons they have assumed a major significance in their relation to the gassing power of doughs. Methods for supplementing the diastatic enzymes or amylases requisite for maintaining a normal level of fermentation in dough have been a major accomplishment of this period. Without such means, and the control methods which must accompany them, the bakers using American hard wheat flours would have been confronted with serious problems. Now the measurement of gassing rate or of diastatic activity has become a routine technique in many cereal laboratories.

A natural consequence has been an increased interest in starch, which

is the substrate from which part of the sugar of fermentation is derived. The late Dr. Mangels was active in this field of study and he demonstrated substantial variations in the properties of starch samples prepared from different types of wheat flours.

Yeast-leavened doughs yield much of the domestic and commercial bread of the world, and the general study of alcoholic fermentation is of interest to the baker. Improved types and strains of yeast grown under controlled conditions in superior media have resulted from these studies. From numerous laboratories have come suggestions for the successful use of these yeasts, and the control of their activities in bread-making, by means of yeast nutrients or dough improvers. Thus the combined activities of many workers have contributed to the production of superior bread of uniform qualities. The proper position of other dough ingredients has become increasingly apparent from such studies.

By a rational application of these principles, improved standardized technique has been developed for conducting baking tests. In the United States the method used successfully by Werner was elaborated upon and studied collaboratively by a committee of the American Association of Cereal Chemists headed successively by Blish, Bailey, Coleman, Geddes, and Swanson. A Canadian committee has also been active in the same field. It is apparent that much good has resulted from these studies, not only in improving and unifying baking test methods, but also in focusing attention upon the specific properties of flour which become evident when tested in various ways through the application of the supplementary modifications.

At the same time, improved mechanical devices have been designed, including dough mixers, fermentation cabinets, ovens with controls and rotating shelves, bread crumb scoring and texture-measuring systems, all tending to increase the accuracy and uniformity of test baking methods.

The period from 1906 to 1921 witnessed a major advance in the art of flour bleaching and at least four new reagents were introduced and employed extensively by flour millers. More recently organic chemical research has disclosed the chemical nature of the yellow pigments. Researches instituted by Bailey in Minnesota and conducted by Ferrari, Markley and others have resulted in quantitative methods for estimating the concentration of these pigments. It appears that xanthophyls are prominent in the mixture with the other carotinoids. Methods now available make it possible to measure the color-removing properties of a bleaching agent with precision.

Together with gassing rate, the physical properties of dough largely

determine the quality of bread that can be baked therefrom. Efforts have been made to measure such properties, notably by Chopin in France, Hankoczy in Hungary, Schofield and Scott-Blair in England, Swanson and Bailey in this country, and others. Several useful devices have emerged from these studies including the extensimeter, farinograph recording dough mixer and stress-meter, each of some service in measuring certain dough characteristics. Similarly, physical tests have been applied to baked products.

The cereal chemist has even borrowed liberally and profitably from the mathematician as is seen by the work of Harris and Treloar.

We can all be proud to be a part of such scientific progress, and to be associated with such a profession.

### Science the Keynote

If we look around our Association of Cereal Chemists we see what appears at first glance to be a motley assembly. We see representatives from milling, baking, malting, yeast, and many other industries. We see laboratory chemists, plant managers, maltsters, salesmen, professors, even editors. What are the ties which hold us together and give us unity of purpose? First, of course, is interest in cereals. But there is much more than that. What distinguishes our members from other laboratory workers, plant managers, salesmen, editors, *etc.*, in the cereal trades?

The tie that binds us together is our devotion to *Science*. We are a scientific association. This distinguishes us sharply from a business organization interested primarily in profits, or a trade association interested in trade conditions, or an engineering organization interested in practical results. It has been well said that it is an engineer's duty to *do*, and a scientist's duty to *know*. This defines our interest without in any way indicating that our functions are any "higher" or any more important than those of the other types of organization named. Each has its proper function and each will perform the greatest service by sticking to its own field.

It is easy then to trace the common thread of *devotion to the science of cereal chemistry* which binds together the members of our Association. If we are laboratory workers, we are not willing to be mere technicians, we must understand the science underlying our analyses. Further, we must understand the meaning of what we do. We must be able to interpret it to others.

If we are salesmen, we depend upon scientific facts in dealing with customers rather than upon mere conversation, and so we are the better salesmen because we are also scientists. If we are operating millers

or bakers we approach our problems from the scientific point of view, looking for facts, applying science wherever possible. Again we are better millers or bakers because we are also cereal chemists. Likewise, the engineers, executives, editors, *etc.*, among our membership all have the scientific approach which unifies their point of view.

One evidence of the truly scientific nature of our Association is that we have always been willing to criticize and test our conclusions. We have not shrunk from the results, even when they demonstrated our own weakness. Let me give four examples.

The basic activity of a mill chemist is his analyses. Yet the group which made up the original Association of Cereal Chemists had for one of its principal activities, exchanging check samples, even though this activity disclosed considerable discrepancies in the analytical results of that day. Second, the one determination characteristic of the cereal chemist is the baking test. Here again we did not shrink from a critical study of this test even though such study completely destroyed our self-complacency and caused considerable antagonism. Third, when the mathematicians questioned the statistical validity of some of our conclusions we welcomed their rather bitter pill and each of us can now write plus or minus the square root of something after our data. Finally the permanent progress of our science resides in our printed papers. Some of our members questioned "what, if anything," our most cherished technical terms really meant. Again we welcomed the criticism, and again we have progressed as a science.

### **A Profession to Be Proud of**

In closing I would say let us never stray from the strictly scientific aims of the A. A. C. C. Wherever we are individually placed let us never abandon our high scientific ideal either as an association or as individuals. Finally, the profession of cereal chemistry has a glorious history, an inspiring present, and a promising future. Let us all be proud of being cereal chemists.

## MINUTES OF THE TWENTY-SECOND ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF CEREAL CHEMISTS

Adolphus Hotel, Dallas, Texas

June 1 to 5, 1936

H. W. Putnam, *Secretary*

Registration of delegates to the Twenty-second Annual Meeting of the American Association of Cereal Chemists, began at 1 p.m., Monday, June 1. Twenty attended a meeting of Local Section officers with the Executive Committee and Officers of the Association from 2 p.m. to 5 p.m., the time being devoted to a discussion of general problems and policies. The Executive Committee and Officers met again in the evening to consider other details of Association business.

Tuesday, June 2

The meeting was called to order at 9:37 a.m. by President Washington Platt. After the invocation by Rowland J. Clark, George Melvin, Past-President of the Association of Operative Millers, brought official greetings from their Forty-first Annual Meeting and an invitation to attend their sessions being held concurrently in the Baker Hotel. He expressed the hope that the co-operative spirit which has existed between the two organizations for so long would continue in the future.

To honor the memory of Charles Edwin Mangels and Clifford Brewster Morrison, members deceased since our Twenty-first Annual Meeting, Harry D. Liggitt led the members in standing for a moment of silent reverence.

The convention program committee consisting of M. J. Blish, Chairman, F. L. Dunlap, H. W. Rohde, R. C. Sherwood, and C. O. Swanson was complimented by President Platt for the excellence of its work. Doctor Blish spoke briefly asking the speakers to observe the self-allotted time limits in order to permit ample discussion of each paper.

Robert Thornton, Dallas Chamber of Commerce, brought an official welcome from the city of Dallas and from the State of Texas this year celebrating its Centennial through the National Exposition at Dallas.

Attention was next directed to the excellence of the work done by the Dallas Local Arrangements Committee consisting of Rolfe L. Frye, Chairman, G. E. Findley, Paul D. Cretien, Paul P. Merritt, Helman Rosenthal, Floyd A. Bleger, and L. W. Francis and by the Ladies' Entertainment Committee consisting of Mrs. G. E. Findley, Chairman, Mrs. Rolfe L. Frye, Mrs. Paul P. Merritt, Mrs. Paul Cretien, and Mrs. Fred Puckhaber. Mr. Frye outlined the activities planned for the week and extended a cordial welcome to all present.

President Platt urged the members to communicate their wishes to the nominating committee consisting of C. G. Harrel, Chairman, Paul Logue, and R. K. Durham, and to make suggestions to the Resolutions Committee, composed of H. V. Moss, Chairman, Rufus A. Barackman, and Clinton L. Brooke.

The address given by President Platt is recorded on pages 470-476 of this issue of CEREAL CHEMISTRY.

Dr. P. C. Mangelsdorf, Agronomist, Texas Agricultural Experiment Station, gave a paper on "Wheat Quality in the Southwest as Viewed by the Agronomist."

Dr. K. S. Quisenberry, Agronomist in Wheat Investigations, U. S. Department of Agriculture, Washington, D. C., outlined the tremendous amount of work involved and the care taken in "Developing and Testing New Wheat Varieties."

Dr. John H. Parker, Agronomist, U. S. Department of Agriculture, Manhattan, Kansas, was introduced.

The meeting was closed at 11:15 a.m.

At a noon luncheon in honor of Past Presidents of the Association, Toastmaster Rowland J. Clark introduced R. Wallace Mitchell, S. J. Lawellin, M. J.



Blish, R. J. Clark, M. A. Gray, C. G. Harrel, L. D. Whiting, R. C. Sherwood, and Mary M. Brooke, as members of an "ancient and honorable society of goats and buck passers."

By appropriate ceremonies Washington Platt was then welcomed to this exclusive membership.

The technical meeting reconvened at 2:00 p.m.

President Platt introduced C. H. Bailey as chairman for the afternoon.

In the absence of Betty Sullivan, Chairman, Claude F. Davis read the general report of the Committee on Methods of Analysis.

Paper—"Report of Sub-Committee on Viscosity," by E. G. Bayfield, read by W. E. Brownlee.

Paper—"The Effect of Different Types of Shortening on White Pan Bread," by W. L. Heald. Discussion by J. R. Katz.

Paper—"Evaluation of the Effect of Milk Solids in Dough Fermentation," by Oscar Skovholt.

Paper—"The Influence of Individual Experimental Milling Technique on Loaf Characteristics," by Max Markley and A. E. Treloar, read by Oscar Skovholt.

Paper—"A Collaborative Comparison of Methods for Estimating the Diastatic Activity of Flour," by Claude F. Davis.

President Platt suggested that action by the Association on the recommendations of the Committees be deferred until the business session.

Paper—"Refractometric Studies of Amylase Activity," by E. Munz and C. H. Bailey, read by Doctor Bailey.

Paper—"Effect of Pressure on Rate of Gas Production in Yeast Fermentation," by R. M. Sandstedt and M. J. Blish, read by R. M. Sandstedt.

Paper—"Identification and Measurement of Factors Governing Diastasis in Wheat Flour," by R. M. Sandstedt, M. J. Blish, D. K. Mecham, and C. E. Bode, read by R. M. Sandstedt.

Paper—"A Comparative Study of Various Methods for Measuring Flour Gassing Power," by B. Frisell, W. J. Eva, and W. F. Geddes, read by D. S. Binnington.

The chair was resumed by President Platt who called on Helman Rosenthal for announcements concerning the golf tournament. The meeting was closed at 4:15 p.m.

A dinner in honor of Dr. M. J. Blish was held at 6:30 p.m. After Paul Logue, as Chairman of the Thomas Burr Osborne Medal Award Committee, had explained the significance of the award, Clyde H. Bailey spoke on "The Work of Morris J. Blish." President Platt then presented the Osborne Medal to Doctor Blish who gave his address, entitled: "The Wheat Flour Proteins."

(Tuesday noon, the wives of members were entertained for luncheon at the Dallas Country Club)

### Wednesday, June 3

President Platt opened the meeting with a business session at 9:00 a.m. The minutes of the twenty-first annual meeting, printed in *CEREAL CHEMISTRY* 12: 419-435 (July, 1935), were referred to but not read, and were approved without objection or correction.

C. G. Harrel presented the report of the Nominating Committee which nominated Harry D. Liggitt, Jr., for President. R. C. Sherwood moved that a unanimous ballot be cast for Harry D. Liggitt, Jr. Seconded by Mrs. Mary M. Brooke. Carried.

The committee nominations for Vice-President were C. H. Bailey, Rolfe L. Frye, and George F. Garnatz; for Secretary, H. W. Putnam; for Treasurer, M. D. Mize; for Editor-in-Chief of *CEREAL CHEMISTRY*, D. A. Coleman; and for Managing Editor of *CEREAL CHEMISTRY*, C. C. Fifield. Mrs. Mary M. Brooke moved the adoption of the report of the Nominating Committee. Seconded by H. O. Gilmer. Carried.

L. D. Whiting moved that nominations for Vice-President be closed. Seconded by Pearl Brown. Carried. Oscar Skovholt and R. C. Alban handled the ballots. R. J. Clark and H. W. Putnam acted as tellers. C. H. Bailey was elected Vice-President of the Association.



Mrs. Mary M. Brooke moved that further nominations for the remaining offices of the Association be closed. Seconded by M. J. Blish who moved that a unanimous ballot be cast for these men for their respective offices. Seconded by Elise Shover. Carried.

Further announcements about the industrial trip and the golf tournament were made by Rolfe L. Frye.

R. J. Clark directed attention to the exhibits of the History Committee which contained the "Scrap Book" of the Association, a complete file of News Letters, pictures and letters from foreign cereal chemists, rare books and pamphlets, and a reproduction of the Leeuwenhoek microscope.

President Platt then turned the meeting over to R. J. Clark as chairman who called on Dr. C. O. Swanson for the "General Report of the Committee on Standardization of Laboratory Baking," who spoke briefly on the work of the committee.

Paper—"The Meaning of Fermentation Tolerance," by R. J. Clark. Discussion by Quick Landis, M. J. Blish, R. M. Bohn, S. F. Brockington, Oscar Skovholt, and Ralph Mitchell.

Paper—"Influence of Type and Size of Pan on Experimental Baking Tests," by Claude F. Davis. Discussion by Victor E. Marx, M. H. Parlin, Quick Landis, and R. C. Sherwood.

Paper—"Correlation of Experimental and Commercial Baking Tests When Using Sponge Doughs," by C. N. Frey, Jacob Freilich, and S. McHugh, read by Jacob Freilich.

Paper—"Proofing to Constant Time vs. Constant Height or Volume," by W. F. Geddes, read by D. S. Binnington.

Paper—"A New Experimental Baking Oven," by R. K. Larmour, read by C. O. Swanson.

Paper—"The Present Status of the 'Standard' A. A. C. C. Baking Test," by M. J. Blish. Discussion by R. M. Bohn, R. Wallace Mitchell, Oscar Skovholt, R. C. Sherwood, Quick Landis, and Charles N. Frey.

The balance of the General Report of the Committee was then given by Doctor Swanson.

A. Kemeny presented the idea that a funnel might be suitably supported and used for both proofing and baking of test loaves.

The meeting was closed at 12:15 p.m.

The ladies enjoyed a Mexican luncheon at the El Fenix Cafe. The afternoon was devoted to a sight-seeing trip to the cotton gin manufacturing plant of the Murray Gin Company, the plant of Procter & Gamble Company, the Texas Centennial Exposition grounds, the Dallas Airport, and through a residential portion of Dallas. The traditional golf tournament was staged concurrently at the Lake-wood Country Club.

#### Thursday, June 4

The meeting opened at 9:10 a.m.

Following some general announcements, President Platt turned the meeting over to L. D. Whiting, chairman for the morning, who gave the general report of the Cake Division of the Committee on Cake-Baking Tests and Self-Rising Flours.

Paper—"The Effects of Formula and Procedure Variables Upon Cake Quality," by John R. Davies.

Paper—"Comparative Baking Results with Various Types of Egg Albumin," by W. E. Stokes. Question by M. D. Mize.

Paper—"Factors Affecting the Basic Cake Formula," by Howard R. Fisher, read by H. D. Liggitt, Jr. Discussion by H. V. Moss and W. E. Stokes.

The general recommendations of the cake-baking test section of the committee were read by Chairman Whiting who then gave the "General Report of the Self-Rising Flour Division" with recommendations for future work.

Paper—"Proteolytic Activity of Some Materials Used in Baking," by Quick Landis and Charles N. Frey, read by Quick Landis. Discussion by C. H. Bailey, F. A. Collatz, William L. Heald, and Charles A. Glabau.

Paper—"The Effects of Protease Increments on the Plasticity of Doughs," by C. H. Bailey and E. G. Rupp, read by C. H. Bailey. Discussion by C. N. Frey and Quick Landis.

Paper—"Baking Quality of Flour as Affected by Certain Enzyme Actions," by J. W. Read and L. W. Haas, read by J. W. Read.

Paper—"The Effect of Chemical Improvers on Proteolytic Action in Relation to the Gas Retaining Capacity of Fermenting Doughs," by J. T. Flohil. Comments by J. W. Read.

Paper—"Further Studies on the Activity of Flour Proteinase," by A. K. Balls and W. S. Hale, read by A. K. Balls. Comments and questions by C. H. Bailey, Quick Landis, J. W. Read, and M. J. Blish.

President Platt again taking charge called members of the Local Arrangements Committee to the front of the meeting room for individual introduction. G. E. Findley urged members to attend the annual banquet, Friday evening.

Dr. Harry G. Knight, Chief of the Bureau of Chemistry and Soils, U. S. Department of Agriculture, was introduced.

After lunch, President Platt called the meeting to order at 1:43 o'clock and placed it in the hands of Mrs. Mary M. Brooke, chairman for the afternoon.

Paper—"Report of Committee on Testing Pie Flours," by C. B. Kress, read by L. D. Whiting.

C. H. Bailey invited members to indicate their interests in the projects of various committees in order to assist the new president in making appointments.

Paper—"Report of Committee on Testing Rye Flours," by L. H. Bailey, read by J. T. Flohil.

Paper—"Report of Committee on Testing Biscuit and Cracker Flours," by W. Reiman, read by Pearl Brown.

Paper—"Report of Committee on Definitions of Technical Terms," by Quick Landis. See page 484, this issue, CEREAL CHEMISTRY.

Paper—"The Usefulness of Viscosity in Evaluating Quality and Strength in Soft Wheats," by E. G. Bayfield and V. Shiple, read by V. Shiple. Discussion by C. H. Bailey, M. H. Parlin, and R. M. Sandstedt.

Paper—"Baking Tests with Added Crude Gluten," by Oscar Skovholt and C. H. Bailey, read by Oscar Skovholt. Question by F. A. Collatz.

Paper—"Elasticity of Dough," by L. J. Bohn and C. H. Bailey, read by C. H. Bailey. Question by J. T. Flohil.

Paper—"The Relative Loss in Pigment Content of Durum Wheat Semolina and Spaghetti Stored Under Various Conditions," by D. S. Binnington and W. F. Geddes, read by D. S. Binnington.

Paper—"A Comparative Study of Spectrographic and Colorimetric Methods for Evaluating the Color of Cereal Products," by H. Johannson, D. S. Binnington, and W. F. Geddes, read by D. S. Binnington.

Paper—"The Relative Macaroni Making Quality of a Number of Durum Varieties," by D. S. Binnington and W. F. Geddes, read by D. S. Binnington.

At 3:55 p.m. President Platt opened a business session.

The Report of the Executive Committee (see page 483, this issue of CEREAL CHEMISTRY) was read by Harry D. Liggitt, Jr.

F. A. Collatz spoke a few words of welcome to Minneapolis for 1937 meeting.

The Report of the Secretary was given by H. W. Putnam, see page 484, this issue of CEREAL CHEMISTRY.

M. D. Mize, Treasurer, commenting on the bankrupt savings account in Kansas City (see report of Executive Committee) stated that the A. A. C. C. had not kept in as close contact as it should have with the condition of the institution involved, but rather had relied to a great extent on the judgment of the A. O. M. Since the A. O. M. always had expressed considerable confidence in the institution by depositing from ten to fifteen times as much as the A. A. C. C., their opinion was considered quite valuable.

D. A. Coleman, Editor-in-Chief of CEREAL CHEMISTRY, stated that 150 new subscribers had been obtained, that the present circulation list is nearly 1000, and that the Journal has had a healthy sale of back numbers—mainly to foreign chemists. He mentioned that the journal goes to nearly every country in the world. Since several small papers are more easily published than one large one, he urged condensation. The only alternatives will be a further increase in the subscription price or serious delay in publishing worth while information.

The results of the work of the Membership Committee were reported by M. D. Mize who stated that new members were obtained mainly through the efforts of individual members. Since two copies of "Cereal Laboratory Methods" had been offered as prizes for securing new members between March 1 and the time of the convention, and since 12 members had obtained one new member each, a drawing was made to determine the winners. Books were awarded L. E. Leatherock and F. P. Siebel, Jr.

The meeting was closed at 4:15 p.m.

Arrangements had been made for the annual picnic at Mosque Point on Lake Worth, west of Fort Worth. The trip to and from the picnic was made in buses and private cars and was well attended.

# Friday, June 5

In opening the meeting at 8:43 a.m., President Platt announced a business session immediately following lunch and then turned the meeting over to H. W. Rohde, chairman for the morning.

Paper—"Report of Committee on Malt Analysis Standardization," by D. A. Coleman. Comments and questions by J. A. LeClerc, R. C. Sherwood, A. D. Dickson, and C. H. Bailey.

Washington Platt in pointing out the necessity for clear definitions suggested that authors either define such terms as are commonly used in more than one sense or refer to the particular meaning as set forth in the reports of the A. A. C. C. Committee on Definitions of Technical Terms.

Paper—"Barley and Malt Studies: II. Experimental Malting of Barleys Grown in 1935," by J. G. Dickson, H. L. Shands, A. D. Dickson, and B. A. Burkhardt, read by A. D. Dickson. Discussion by C. H. Bailey, D. A. Coleman, J. W. Read, George Bratton, J. A. LeClerc, R. C. Sherwood, Elsie Singruen, and H. W. Rohde.

Paper—"Barley and Malt Studies: III. Determination of Kernel Weight," by H. L. Shands. Discussion by H. W. Rohde and D. A. Coleman.

Paper—"Biochemical Distinction of Barley Varieties," by J. H. Shellenberger and C. H. Bailey, read by C. H. Bailey. Questions by D. A. Coleman and George Bratton.

Paper—"Evaluation of Malt," by S. Laufer, read by Elsie Singruen.

Paper—"Experimental Malting Equipment of the U. S. Department of Agriculture," by D. A. Coleman. Comments by C. H. Bailey and J. A. LeClerc.

Paper—"Apparent Specific Gravity of Some Cereals and Cereal Products by Volumenometer," by H. C. Gore, read by G. W. Kirby.

Paper—"Review of the Brewing Literature for 1935 with Special Reference to Barley, Malt, and Cereal Products," by Elsie Singruen.

Paper—"Chemical Laboratories and Plant Control of the Tuborg Breweries in Copenhagen, Denmark," by B. Krause. Two reels of motion pictures were used to illustrate the paper, which was presented by Christian Rask.

It was moved by Washington Platt, seconded by Elsie Singruen, to extend a vote of thanks to B. Krause and the Tuborg Breweries for the loan of the film. Carried unanimously.

The meeting was closed for luncheon at 12:15 p.m.

President Platt called the business meeting to order at 2:06 p.m.

An informal report was given by Charles A. Glabau, chairman of the Employment Committee, who stated that whereas thirty-nine chemists had applied to the committee only a few of them had experience in cereal chemistry. Also that while assistance was given six companies in finding trained men, there is no evidence that the positions were filled by applicants available to the Committee.

T. R. West, chairman of the Publicity Committee, reported the activities of his group as shown on page 487, this issue, CEREAL CHEMISTRY.

R. C. Sherwood, chairman of the Inter-Relations Committee, read the report appearing on page 486 of this issue of CEREAL CHEMISTRY.

During the Convention, communications had been received from members and others. Those remaining unread were presented at this time. Altogether greetings were received from Avery Dunn, E. A. Fisher, W. F. Geddes, D. A. MacTavish, Leslie R. Olsen, Dr. and Mrs. E. E. Smith, A. A. Schaal, George R. Stadler and Betty Sullivan. Invitations to hold conventions were presented from the cities of Buffalo, Cincinnati, Chicago, Milwaukee, Minneapolis, New York, and Washington.

The report of the Auditing Committee was read by Washington Platt. It appears on page 484 of this issue of CEREAL CHEMISTRY.

The work of the Traffic Committee was acknowledged. Their report is given on page 487.

The report of the History Committee, given on page 486, was read by Rowland J. Clark.

The reports of the technical and scientific committees were next considered. Since the Committee on Methods of Analysis had offered no new methods for approval, their report was accepted at once.

The recommendations of the Malt Analysis Standardization Committee were accepted. The recommendations were: That the methods of analysis of the American Society of Brewers' Chemists for barley malt be adopted by this Association as official (first reading), with the exception of the method for the determination of diastatic power; that the method for the determination of diastatic power be held in the "tentative" status for one year pending study before being recommended for adoption; and, that methods for the analysis of malt adjuncts now being sponsored by the Association of Official Agricultural Chemists as "tentative" be adopted by this Association as tentative methods for the purpose of further study.

The report of the Committee on the Standardization of Laboratory Baking was accepted.

The change in the official cake baking procedure, recommended by the Committee on Cake Baking and Self-Rising Flours, substituting fresh or frozen egg whites for dry egg albumin was adopted.

The report of the Committee on Testing Biscuit and Cracker Flours was accepted since further work is being recommended before the adoption of the methods as official.

The progress report of the Committee on Testing Rye Flours was accepted.

The report of the Committee on Definitions of Technical Terms, given on page 484, was accepted.

Announcements relative to the annual dinner dance were made by R. L. Frye, chairman of the local arrangements committee.

Acceptance of the report of the Resolutions Committee was moved by Chairman H. V. Moss whose report appears on page 488. Seconded by F. A. Collatz. Carried.

The new officers, Harry D. Liggitt, president; C. H. Bailey, vice-president; H. W. Putnam, secretary; M. D. Mize, treasurer; and D. A. Coleman, editor-in-chief of CEREAL CHEMISTRY (C. C. Fifield, managing editor of CEREAL CHEMISTRY, being absent from the convention), were presented. Washington Platt turned the Presidential Gavel over to Mr. Liggitt who made a short speech of acceptance.

R. C. Sherwood moved the adoption of the following:

"Resolved: that the members of the A. A. C. C. desire to express at this time their appreciation of the fine work that has been done by the retiring President, Washington Platt, during the past year. Be it further resolved: that the president-elect appoint a committee to draft a testimonial expressing these sentiments, and that this be suitably engrossed and presented to the retiring president, Mr. Platt, on some appropriate occasion to be arranged by his Local Section." Seconded by C. H. Bailey and Ralph W. Mitchell. Unanimously adopted.

President Liggitt appointed R. C. Sherwood, C. H. Bailey, F. L. Dunlap, and Ralph W. Mitchell to serve on the committee to prepare this testimonial.

F. L. Dunlap was presented as the chairman of the final session.

Paper—"Oven-Spring of Dough as Influenced by Sugar, Salt, and Yeast," by W. O. Whitcomb, read by title.

Paper—"Practical Suggestions for the Preparation of Standard Solutions," by W. O. Whitcomb, read by title.

Paper—"Some Observations on Rapid Methods of Ashing Cereal Products," by L. H. Bailey, read by J. A. LeClerc. Discussion by A. A. Towner, M. D. Mize, W. E. Stokes, and F. A. Collatz.

Paper—"Some Observations on the Structure of the Wheat Starch Granule," by J. R. Katz in collaboration with M. C. Desai, read by J. R. Katz. Discussion by C. H. Bailey.

Paper—"Report of the U. S. Department of Agriculture Committee on Bread Flavor," by Florence B. King. Discussion by Washington Platt, Bert D. Ingels, F. L. Dunlap, C. A. Glabau, R. C. Sherwood, and F. A. Collatz.

Paper—"Definite Examples in Which the Baker Has Been Benefited by the Cereal Chemist," by R. L. Gerdes. Mr. Gerdes brought the greetings of the American Society of Bakery Engineers. Comments by R. C. Sherwood.

Paper—"Further Studies on the Growth of Bread Molds," by G. W. Kirby, L. Atkin, and C. N. Frey, read by G. W. Kirby.

Paper—"Recent Progress in Cereal Chemistry," by Clinton L. Brooke, read by Rufus A. Barackman.

President Liggitt declared the Twenty-Second Annual Meeting adjourned at 5:27 p.m.

Many members attended the dinner dance in the evening at the Dallas Country Club at which prizes were distributed to the winners of the golf tournament.

### Report of the Executive Committee

Harry D. Liggitt, Jr., *Chairman*

This has been a rather uneventful year so far as any weighty decisions were concerned. There has been the utmost co-operation and accord between the members of the Committee throughout the year, which has made the Chairman's job comparatively easy.

Due to a change in business connections by our Treasurer, Mr. Mize, the committee authorized a change in banking connections from Omaha to the Rutherford National Bank of Rutherford, N. J.

We are sorry to report that the Benefit Building & Loan Company of Kansas City, in which \$2,000 of our funds were invested in 1926, has passed into the hands of the receivers. At present it is impossible for us to report as to what returns we may expect from this investment. We have filed our proof of claim with the receiver, but have had no report as to terms of settlement. Outside of this, the finances of our association are in a healthy condition.

Last year's executive committee, acting within the powers granted it by the Association, decided to abandon the rotating policy for one year and placed the 1936 convention in Dallas. This consequently meant the holding of two consecutive conventions in the Southwest. According to the rotating schedule, the convention in 1937 should be held in the Northwest, as the 1934 convention was held in the East. Due to the large vote which was given Minneapolis for the 1936 convention, and since the last convention held there was in 1928, the committee has decided on Minneapolis for the convention city for 1937.

The committee suggests two possible meeting dates for our Minneapolis Convention, namely, the week of May 24 to 29 and the week of May 31 to June 4, the latter being preferred.

The charter for the Cincinnati Section was approved and signed by the committee. We are glad to welcome this new section and we know that it will be a fruitful addition to our Association.

After careful study, the executive committee approved the statement of policy as to Local Sections which was printed on page 219 of the March, 1936, News Letter.

It was with a great deal of pleasure that the committee authorized the purchase of the Osborne medal, which was presented to Dr. M. J. Blish on Tuesday evening, June 2, 1936.

The committee decided to continue publishing the proceedings of the Annual Meeting, but limited the cost of reporting and publishing the notes of the Twenty-Second Annual Meeting to \$300.00.

The committee approved the immediate publishing of the revised Constitution in CEREAL CHEMISTRY and that the appropriation of \$28.50 made on March 10, 1936, be used in supplying the Secretary with the number of reprints necessary to meet his needs.

The Committee, recognizing the great importance and value of the Inter-Relations Committee, appropriated a maximum amount of \$75.00 to be used in carrying on its activities.

The committee, recognizing the fact that CEREAL CHEMISTRY has continued to grow in size, quality, value and circulation and that the work entailed has grown in proportion, has voted that the salary of the Editor-in-Chief be raised from \$300.00 to \$400.00 per annum. That the assistant Editor be raised from \$300.00 to \$400.00 per annum, and that \$150.00 be voted for extra clerical assistance, to be used at the discretion of the Editor-in-Chief. These arrangements are to be tried out for a period of one year. We feel that the income will cover this extra expense.

The committee, due to the fact that it is costing more to publish CEREAL CHEMISTRY, voted to increase the subscription rate of CEREAL CHEMISTRY to non-members and foreign subscribers from \$5.00 to \$6.00 per annum. The foreign subscriptions to be proportionately higher, as is now the case.

The committee designated the following as associate Editors of CEREAL CHEMISTRY, Mary M. Brooke, C. O. Swanson, Clinton L. Brooke, and W. F. Geddes.



The committee designated Washington Platt to send copies of "Cereal Laboratory Methods," suitably inscribed to J. C. Mangels, Ruth Elizabeth and Dorothy Mangels.

With the additions as stated above, the budget, as submitted by Mr. Mize to the committee in session during the Bakery Engineers' convention, was approved. As you can see by our Treasurer's Report, we have come through another year with all departments and activities of the Association showing a surplus.

The Executive Committee passed a resolution to the effect that, as the Committee interprets the Constitution, each Corporation Member may have one representative, who may attend National and local meetings, may have the privilege of the floor, but has no National vote. This representative may have any other privileges accorded associate members.

We have grown to be an Association of over five hundred members through the judicial handling of all affairs connected with our Association. Let us hope that this state of affairs may continue and that the details of running our Association may not become so heavy as to be a burden to any of the officers. We must guard against this.

The Chairman wishes to express his appreciation to the members of the committee and to the Treasurer and Secretary for their help and co-operation during the past year.

#### **Report of the Secretary**

H. W. Putnam

Mr. Mize has regularly covered changes in membership and the financial condition of the Association. His admirably clear report for 1935 appeared in the May, 1936, CEREAL CHEMISTRY while the minutes of the twenty-first annual meeting were printed in July, 1935. Merely because a report of other work is now offered, you must not conclude a new activity is represented. Mr. Mize has simply been relieved of part of the work he formerly carried alone, by having your Secretary handle "the general correspondence of the Association" and maintain "contacts with the local sections."

Among the specific tasks undertaken were: the preparation for Executive Committee approval of the Cincinnati Section Charter, the preparation of the amended A. A. C. C. constitution for printing, the collection of data on the membership and activities of the local sections, the classification of the membership list to show section affiliations on the list soon to be printed, the mailing of letters of welcome to new members to place them in contact with local section activities, and the collection of some material for the News Letter.

#### **Report of the Auditing Committee**

H. K. Parker, *Chairman*

We have examined the books of Mr. Mize and have found, to the best of our knowledge and belief, that everything is quite in order.

There is one item which we believe should be discussed by your Committee and that is the \$2,000.00 Building and Loan held at Kansas City. It is our opinion that this should be written off and possibly some reserve should be set up against it.

#### **Report of the Committee on Definitions of Technical Terms**

Quick Landis, *Chairman*

We deeply regret the loss, through death, of the stimulating influence of one of our members, C. B. Morison. His wide experience and philosophical outlook have been of great assistance in improving our nomenclature.

It is our belief that the most valuable contribution of this committee is not its report but the discussion which accompanies it. Therefore we propose to submit definitions based on previous discussions and published articles, and invite more. First, we would like to quote from a letter received from President Platt, which we believe, would be an excellent motto for this committee to adopt: "I agree with you that clear thinking is very important in Cereal Chemistry, and that a clear definition of what we mean by the terms that we use is very helpful in this regard. It isn't so very important whether or not we officially adopt certain terms, but it is



important that we realize the discrepancies in our meanings and try to improve them. A discussion of such questions at the convention and in the pages of CEREAL CHEMISTRY is most helpful to all concerned, including our English friends."

Thus we recommend to the chairman of the succeeding committee that no absolute or official standardization of terms be adopted, but that each committee submit a glossary of terms which represents to the best of its ability the current meaning to be ascribed to them. When objection and discussion regarding a particular definition ceases, it may be assumed automatically to be adopted until newer knowledge demands refinement. For the present the committee invites your attention to the following glossary. Compare it with that given in CEREAL CHEMISTRY 10: 463. Please feel free to interrupt at any time with comments, or if you prefer to think them over do not fail to present them at the close of this report.

*Diastatic activity:* The conversion of starch by enzymic means.

*Lintner diastatic activity:* Saccharifying enzyme concentration of any diastatic material. One Lintner unit is defined as that amount of the saccharifying component which when supplied with excess soluble starch under standard conditions will convert the starch at the rate of 70.3 mg. anhydrous maltose per hour at the beginning of the reaction. The Lintner value, °L, is the number of units per gram of material.

*Starch liquefying activity:* Liquefying or dextrinizing enzyme concentration of any diastatic material. One liquefying unit is defined as that amount of the liquefying or dextrinizing component which will convert gelatinized starch at the rate of 25 mg. per minute at the beginning of the reaction under standard conditions.

*Autolytic diastatic (saccharogenic) activity:* Average rate of formation of reducing sugars in flour calculated as milligrams of anhydrous maltose per hour per 10 gm. of flour (Rumsey units) during autolysis under standard conditions, and limited to the first hour of measurement.

*Diastatic sugar level:* The potential sugar level in the absence of added sugars.

*Limiting diastatic activity:* Deleted; New studies have shown it to be meaningless.

*Standard loaf:* Idealized concept of a loaf of arbitrary textural characteristics and volume, used as a reference point when comparing the results of baking tests. Obviously there may be several standards, which we hope may eventually be set by the Baking test committee.

*Response:* Difference in textural characteristics or volume resulting from the reaction of the system to any specific condition or substance. Responses are positive, negative or neutral. There may be textural response, response in loaf volume, etc., bromate response, mixing response, etc.

*Tolerance:* Amount of substance or condition required to produce neutral response.

*Fermentation tolerance* is commonly used to convey three meanings:

1. Amount of fermentation over which positive response is maintained with gassing factor eliminated.
2. Length of time over which an adequate gassing rate is maintained.
3. Complex of these two: Length of time over which a standard loaf may be produced. It should be noted that the formula used is a large factor in this concept.

*Strength:* No change from 1935 report.

Rheological definitions related to Cereal Chemistry:

*Consistency:* Consistency is that property of a material by which it resists permanent change of shape, and is defined by the complete force-flow relation. The terms may be applied to either fluids or solids, for example, consistency of iron, clay slip, syrup or butter (Latin, con, together and sisto, stand).

*Plasticity:* A solid is plastic when it can be readily molded into a desired form. The shearing stress must of course exceed the yield value, and liquids do not exhibit plasticity because they do not retain their shape and therefore cannot be molded advantageously. Plasticity is that property of a solid in virtue of which it not only resists permanent change of shape but it resists relatively more and more as the shearing stress is lowered. Plasticity may not be defined quantitatively because it is a complex property made up to yield value and mobility or their equivalents. The opposite of brittle.

*Yield value:* The minimum shearing stress in dynes per square centimeter required to produce continuous deformation in a solid. One of the quantitative factors in plasticity.

**Mobility:** The measure of the rate with which a solid is continuously deformed after the yield value has been exceeded. The second quantitative factor in plasticity. Quantitative: The mobility is measured by the velocity in centimeters per second given to either of two planes one centimeter apart by a shearing stress of one dyne per square centimeter in excess of the yield value, the space between the planes being filled with the plastic material. Mobility is a more general term than fluidity, the latter being the mobility when the yield value is zero (Latin—mobiles, movable). The reciprocal of stiffness. Stiffness is a more general term than viscosity, the latter being the stiffness when the yield value is zero.

**Elasticity:** When substances have been compressed they tend to recover their volume as soon as the compression is removed. All fluids have perfect elasticity of volume. Elasticity of shape refers to spontaneous return of a substance after deformation to its former shape. The term is used in two distinct senses. According to one a substance is highly elastic which is easily deformed and quickly recovers, i.e., it depends upon the amount of the deformation or recovery. According to the second usage, that substance is the most elastic which most completely recovers its shape after deformation. Elasticity should be measured according to the first definition and the lack of perfect recovery used to calculate the plasticity. Elasticity of volume is measured by the compression in cc. of 1 cc. of material by a pressure of one dyne per square centimeter.

**Ductility:** The capacity for deformation or extension without rupture by drawing or other process involving tension. A property of low yield value, low mobility with adequate cohesion.

### Report of the History Committee

Rowland J. Clark, *Chairman*

The work of the History Committee during the past year has been varied. Some time has been spent in writing up the Association activities which have occurred since 1930. Clippings announcing notable happenings have been taken from the trade magazines and preserved in the Association scrap book.

The most important work of the committee has been the collection and display of historical relics during the convention. In organizing this exhibit many chemists residing in European countries were invited to attend the Dallas meeting and convey their greetings in person, or, if a visit was impossible, to send photographs of their laboratories and reviews of their cereal problems. In addition, 36 cereal men in this country were invited by personal letters to contribute to our convention exhibit. The entire membership was invited through the News Letter to participate.

The response from our foreign friends as well as from our members in this country has been very gratifying as an inspection of the exhibit has demonstrated. The History Committee wishes to express its sincere appreciation for the splendid co-operation of all those contributing to make its display a success. It feels especially indebted to our President, Washington Platt, for his suggestion which prompted the entire undertaking and to Paul Merritt, a member of the local arrangements committee, for his kindness in supplying the necessary containers for the exhibit.

### Report of the Inter-Relations Committee

R. C. Sherwood, *Chairman*

The Inter-Relations Committee was formed by President Platt for the avowed purpose of encouraging a more general recognition of the chemists and biologists as essential factors in the development of the cereal industries, in accordance with the clause in Article II of our constitution.

Numerous suggestions for activities of the committee have been discussed, and the initial steps have been undertaken. Members of the committee have agreed that the program should be organized on a long-time basis to obtain the best results in our efforts to gain greater appreciation for the accomplishments of the cereal chemists. It is not intended that the work of the Inter-Relations Committee will interfere in any way with that of the Publicity Committee. The objectives of the two are somewhat different, but it is expected that the two committees will co-operate in order that there will be no duplication of efforts.

It may be possible to use some phases of the work of the American Chemical Society as a pattern, as it is generally agreed that their efforts to impress the American public with the value of the chemist in our scheme of life have been well rewarded.

The work of the committee the first year has consisted of drawing up a program for the future and determining the best means of attracting the attention of people most directly concerned with the work of cereal chemists. With the assistance of our local sections, the committee has prepared a selected mailing list of persons we think would be interested in information regarding our association and cereal chemists in general. This list will be used for mailing reprints of President Platt's address at this meeting and other literature that is available later. It is planned that later in the year an attractive leaflet citing significant facts regarding our Association and permanent accomplishments of cereal chemists will be prepared for distribution.

A request is being made to the Executive Committee for a small fund to defray the expenses of printing and mailing a limited amount of such material. The committee hopes to aid and advise local sections in organizing some of their programs and is encouraging the planning of at least one program a year which will be of real interest to leaders in the cereal industries. Such a program should be sufficiently attractive to induce them to accept invitations to attend a few of our meetings and become acquainted with cereal chemists and their activities.

The committee recommends that future committees continue the work which has been initiated and expand the program somewhat as opportunity and available funds permit.

#### **Report of the Publicity Committee**

*T. R. West, Chairman*

The Publicity Committee, consisting of Messrs. Marx, Glabau, Richards, Brooke, Frye, Putnam, and West, have for the past year endeavored to keep the activities of the Association as much before the public as possible. Through the medium of thirty-eight publications in the United States, Canada, and England news of the Association's activities and members has been passed on to the "consuming public." Practically every meeting of the local sections has been publicized by some member of the committee and other items of news interest have likewise been given distribution.

Prior to the Dallas convention, this committee asked for copies of abstracts of papers appearing on the convention program with the result that material was received and circulated covering some twenty papers on the program. Unfortunately, a considerable number of papers received no such publicity because of failure to furnish the requested material. This is to be regretted because much valuable material was thus kept from the trade journals handling our releases. During the convention constant contact was maintained with representatives of the local Dallas press, through which channel daily news of the meetings was disseminated.

The Publicity Committee wishes to take this opportunity of thanking the editors of these publications for their co-operation and their interest in the affairs of the Association.

#### **Report of the Traffic Committee**

*J. D. Veron, Chairman*

On comparing the railroad facilities and trunk line connections, the MKT. was designated as the Dallas Convention Special. This train left St. Louis, Sunday, May 31, at 6:30 p.m., and was joined at Muskogee, Oklahoma, June 1 by the MKT. Dallas Convention Special coming from Kansas City where it had left May 31 at 10:10 p.m. Due to efforts of the Association, the Centennial rate was advanced from June 1 to May 29, which allowed each member to be benefited by the lowest railroad fare possible.

Each member of the Traffic Committee assisted members of his particular district with traffic information.

### Report of the Committee on Resolutions

H. V. Moss, *Chairman*

Whereas, The American Association of Cereal Chemists will today complete another annual convention; and,

Whereas, its notable success has been largely due to the unstinted efforts of the officers and committees of this Association,

Therefore, be it resolved that the thanks of the Association be extended to Washinton Platt, President; Harry D. Liggitt, Vice-President; H. W. Putnam, Secretary; M. D. Mize, Treasurer; and to the Program Committee, M. J. Blish, Chairman; the Local Arrangements Committee, R. L. Frye, Chairman; the Ladies' Entertainment Committee, Mrs. G. E. Findley, Chairman; and to the other committees and members who have contributed to the program and activities of the Association.

Be it further resolved that we express our appreciation to D. A. Coleman, Editor-in-Chief, and to C. C. Fifield, Managing Editor of CEREAL CHEMISTRY, for their continued good work.

Be it further resolved that we express our thanks to R. J. Clark for his invocation at the opening of the convention.

Be it further resolved that we express our thanks to Mr. Robert Thornton for his cordial welcome to the City of Dallas and to Mr. George Melvin, Past President of the Association of Operative Millers, for his words of greeting from the Association of Operative Millers on the opening day of our Convention.

Be it resolved that we express our appreciation to Dr. P. C. Mangelsdorf of the Texas Agricultural Experiment Station, to Dr. A. K. Balls, to Dr. Florance B. King, and to Dr. K. S. Quisenberry of the United States Department of Agriculture for their excellent presentations before this Association.

Be it resolved that the appreciation of the Association be conveyed to Dr. B. Krause for the loan of the interesting films showing the Tuborg Breweries of Copenhagen.

Be it resolved that we express our appreciation to R. L. Gerdes, of the American Society of Bakery Engineers, for his excellent paper.

Be it further resolved that we express our appreciation for the golf trophies to: The American Molasses Company of New York; The Central Scientific Company; Green Bros.; The Laboratory Construction Company; The Lever Bros. Co.; The Monsanto Chemical Company; The Morten Milling Company; The Stanard Tilton Milling Company; The Victor Chemical Works; The Wallace & Tiernan Company; The Wesson Oil & Snowdrift Sales Company, and The Borden Company.

Be it further resolved that we express our thanks to Mr. H. Fuller Stevens, Manager of the Hotel Adolphus, for the real hospitality extended to the members of the Association.

Be it resolved that our sympathy and wishes for a speedy recovery be conveyed to our fellow member, J. M. Lugenbeel, who has been prevented through illness from attending this convention.

Whereas, during the past year, two of our members were deceased, be it resolved that we express our sincere regret at the passing of our late fellow members, C. E. Mangels and C. Brewster Morison, both of whom contributed so much to this Association. Be it further resolved that the Secretary be instructed to convey to their families the deep sympathy of the Association.

Whereas, The Pacific Northwest Section is planning to hold a meeting on June 11, 12, and 13, 1936,

Be it resolved that we extend our best wishes for its complete success, and further that since L. E. Leatherock is planning to attend this meeting, he personally present these wishes to P. O. Hastings, Chairman of the Pacific Northwest Section, and that he express to the members of the Pacific Northwest Section our desire that they may all find it possible to attend the National Convention of our Association to be held in Minneapolis in 1937.

Executive Committee

Dr. C. H. Bailey, <i>Chairman</i>	W. L. Heald,
Washington Platt	H. D. Liggitt, Jr.
Mary M. Brooke	

Membership Committee

Elsie Singruen, <i>Chairman</i>	Bert D. Ingels
F. A. Collatz	C. B. Kress
J. B. Merryfield	G. Norman Bruce
William R. Green	Charles A. Glabau
George R. Stadler	G. E. Findley
H. V. Moss	J. D. Stone
Edgar L. Ulrey	Fred A. Wheeler
H. A. Murray	

Committee on Methods of Analysis

To be announced later.

Malt Analysis Standardization Committee

D. A. Coleman, <i>Chairman</i>	A. D. Dickson
H. W. Rohde	J. A. Anderson
Elsie Singruen	L. E. Leatherock
G. S. Bratton	R. E. Hasselgren

Standardization of Laboratory Baking Committee

C. F. Davis, <i>Chairman</i>	C. O. Swanson
W. F. Geddes	R. K. Larmour
C. N. Frey	G. Moen
M. J. Blish	G. Garnatz

Committee on Cake Baking and Self-rising Flours

L. D. Whiting, <i>Chairman</i>	R. J. Clark
J. R. Davies	R. A. Barackman
H. R. Fisher	H. V. Moss
W. E. Stokes	H. W. Putnam
J. W. Montzheimer	

Committee on Testing Biscuit and Cracker Flour

Walter Reiman, <i>Chairman</i>	C. O. Oppen
Pearl Brown	C. T. Everet
J. Micka	C. C. Armuth
R. M. Bohn	

Committee on Testing Pie Flours

To be announced later.

Committee on Testing Rye Flours

To be announced later.

Committee on Definitions of Technical Terms

Quick Landis, <i>Chairman</i>	Clinton Brooke
-------------------------------	----------------

Committee on Employment

C. A. Glabau, <i>Chairman</i>	T. R. Aitken
E. B. Working	H. W. Putnam
Max Markley	

## Publicity Committee

T. R. West, <i>Chairman</i>	C. L. Brooke
R. L. Frye	D. A. MacTavish
V. E. Marx	C. A. Glabau
P. O. Hastings	W. A. Richards

## Committee on Osborne Medal Award

Paul Logue, <i>Chairman</i>	C. G. Ferrari
C. L. Alsberg	C. H. Bailey
M. J. Blish	

## Inter-Relations Committee

R. C. Sherwood, <i>Chairman</i>	F. L. Dunlap
C. G. Harrel	F. L. Gunderson
G. F. Garnatz	Washington Platt

## Resolutions Committee

To be announced later.

## Auditing Committee

H. K. Parker, <i>Chairman</i>	B. R. Jacobs
C. A. Glabau	

## Traffic Committee

G. Norman Bruce, <i>Chairman</i>	J. D. Stone
J. D. Veron	W. L. Haley
Bert Ingels	

## History Committee

R. J. Clark, <i>Chairman</i>	L. R. Olsen
R. W. Mitchell	

## Nominating Committee

To be announced later.

## Convention Program Committee

Miss Betty J. Sullivan, <i>Chairman</i>	R. K. Durham
---	--------------

To be completed later.

## Local Arrangements Committee

F. A. Collatz, <i>Chairman</i>
--------------------------------

To be completed later.

## REGISTRATION OF CONVENTION, DALLAS, TEXAS

June 2-5, 1936

## Members

R. C. Alban	L. R. Bowman, Jr.	F. A. Collatz
C. H. Bailey	G. S. Bratton	Paul Cretein
R. A. Barackman	S. F. Brockington	J. R. Davies
D. S. Binnington	Mary Minton Brooke	Claude F. Davis
H. E. Bishop	E. B. Brown	J. M. Doty
F. A. Bleger	Pearl Brown	F. L. Dunlap
M. J. Blish	W. E. Brownlee	R. K. Durham
Chas. E. Bode	Howard A. Clark	A. D. Dickson
R. M. Bohn	Rowland J. Clark	G. E. Findley
J. A. Bourne	D. A. Coleman	Henry Flick



John T. Flohil  
L. W. Francis  
E. N. Frank  
J. Frelich  
Charles N. Frey  
Rolfe L. Frye  
George Garnatz  
John Giesecke  
H. O. Gilmer  
C. A. Glabau  
M. A. Gray  
O. W. Harper  
C. G. Harrel  
W. L. Heald  
A. E. Herron  
Marjorie Howe  
H. P. Howells  
B. D. Ingels  
Roy Irvin  
L. E. Jackson  
H. H. Johnson  
J. R. Katz  
A. Kemeny  
G. W. Kirby  
Howard M. Lair  
A. L. Lancaster  
Quick Landis  
S. J. Lawellin  
L. E. Leatherrock

J. A. LeClerc  
H. D. Liggitt  
Paul Logue  
Fred J. Lumsden  
F. L. MacCreary  
C. H. MacIntosh  
Victor E. Marx  
Jas. E. Mastin  
L. Mennel, Jr.  
Paul P. Merritt  
P. E. Minton  
H. E. Mitchell  
H. S. Mitchell  
R. W. Mitchell  
M. D. Mize  
Elmer Modeer  
H. V. Moss  
C. T. Newell  
Harry Obermeyer  
M. H. Parlin  
L. H. Patten, Jr.  
F. D. Patterson  
Washington Platt  
R. B. Potts  
H. W. Putnam  
Glenn L. Pyle  
Christian Rask  
J. W. Read  
W. C. Rohrbaugh

K. S. Rohrbaugh  
F. N. Rogers  
Hugo Rohde  
Helman Rosenthal  
E. M. Ryan  
R. M. Sandstedt  
R. C. Sherwood  
V. Shiple  
Elise C. Shover  
Elsie Singruen  
Oscar Skovholt  
M. W. Steeples  
Wesley R. Steller  
W. E. Stokes  
Clarence Stull  
C. O. Swanson  
W. B. Thrasher  
A. A. Towner  
N. F. True  
C. G. Vaupel  
James D. Veron  
C. C. Walker  
T. R. Warren  
Lewis White  
Stewart N. White  
L. D. Whiting  
Harry R. Wick  
Martin Wise  
Sven Young

#### Visitors and Guests

Mrs. C. H. Bailey  
A. K. Balls  
D. L. Boyer  
W. A. Brom  
Norris Brown  
B. H. Burkhardt  
Mrs. D. S. Binnington  
Mrs. M. J. Blish  
Mrs. G. S. Bratton  
Mrs. W. E. Brownlee  
Elsie Cretein  
Mrs. C. F. Davis  
Ruth Findley  
Mrs. L. W. Francis  
Mrs. Rolfe L. Frye  
T. G. Fletcher  
Mrs. Geo. Garnatz  
Mrs. John Giesecke  
Phil Goldfisch  
T. L. Haberkorn  
Margarita Harding  
Mrs. W. L. Heald  
Roy E. Henry  
Mrs. Henry P. Howells

Mrs. L. E. Jackson  
Florance B. King  
Mrs. Howard Lair  
Constance Landis  
Mrs. S. J. Lawellin  
Mrs. L. E. Leatherrock  
John B. Levert  
Mrs. H. D. Liggitt  
Mrs. Paul Logue  
Mrs. C. H. MacIntosh  
Mrs. Victor Marx  
C. R. McClehue  
Mrs. L. Mennel, Jr.  
Mrs. Paul P. Merritt  
Lois E. Mitchell  
Mrs. R. Wallace Mitchell  
E. M. Paget  
A. Pitann  
Calvin J. Pitt  
Mrs. M. H. Parlin  
Mrs. F. D. Patterson  
Louis S. Potts  
Mrs. R. B. Potts  
P. W. Preston

Fred Puckhaber  
Mrs. G. L. Pyle  
O. H. Raschke  
J. W. Read  
Mrs. K. S. Rohrbaugh  
Mrs. F. N. Rogers  
H. L. Shands  
Mrs. R. C. Sherwood  
C. H. Stafford  
Mrs. Wesley Steller  
Mrs. W. E. Stokes  
Wm. Stoneman, Jr.  
Mrs. Clarence Stull  
Mrs. C. O. Swanson  
Mrs. W. A. Towner  
Mrs. C. G. Vaupel  
Mrs. C. C. Walker  
L. Werthan  
T. R. West  
Mrs. T. R. West  
H. M. Wight  
Daniel Wing  
Mrs. Martin Wise

## THE CONSTITUTION OF THE AMERICAN ASSOCIATION OF CEREAL CHEMISTS<sup>1</sup>

### Article I

#### *Name*

The name of this organization shall be *The American Association of Cereal Chemists*.

### Article II

#### *Purposes of the Association*

The purposes of this Association are (1) the encouragement and advancement of scientific and technical research in cereals and their products, particularly in milling and baking, but including also other industries in which cereals and their products are utilized, (2) the study of analytical methods used in cereal chemistry and the development and adoption of uniform (or standard) methods of examination and analysis, (3) the promotion of the spirit of scientific co-operation among all workers in the field of cereal knowledge, (4) the maintenance of high professional standards in the Association as conditions of membership and (5) to encourage a more general recognition of the chemist and biologist as essential factors in the development of the cereal industries. In accordance with these purposes this Association shall conduct a journal in which contributions to the scientific knowledge of cereals, their products and technical application shall be published for the encouragement and advancement of the science. It shall hold meetings for the discussion of cereal knowledge and the promotion of research and technical co-operation among its members.

### Article III

#### *Membership*

*Section 1.* The membership of this Association shall be divided into three classes (1) active, (2) honorary, and (3) corporation.

*Section 2.* The active membership of this Association shall be restricted to—

(a) those persons having at least two years of chemical training in a college or university which has four years of high school work as a requirement for admission.

(b) those persons presenting evidence that they have the equivalent of (a) in training or experience, a part of which must consist of at least three years practical experience.

*Section 3.* Application for active membership shall be made in writing to the Treasurer of the Association, and the applicant must be recommended by at least one active member of the Association.

*Section 4.* Applications for active membership when qualifications of applicant fully meet requirement of Section 2 (a) will be passed upon and approved by the Treasurer, but in all other cases the Treasurer will refer the application to the Executive Committee of the Association, their decision to be final.

*Section 5.* Honorary members may be elected by a three-fourths majority vote of the active members present at any general meeting, the candidate to be first proposed by one or more active members to the Executive Committee, who in turn shall report on the qualifications of the candidate to the general meeting.

*Section 6.* Corporations that are interested in or concerned with the use of cereals or cereal products may become corporation members upon application to the Treasurer.

<sup>1</sup> As amended by the Association assembled in Convention at Denver, Colorado, June 6, 1935.

## Article IV

### *Officers*

*Section 1.* The elective officers of this Association shall be six in number: namely, President, Vice-President, Secretary, Treasurer, Editor-in-Chief of CEREAL CHEMISTRY, and Managing Editor.

*Section 2.* Active members only shall be eligible to hold elective offices of the Association.

*Section 3. Election of officers*

(a) The President at or preceding each general meeting shall appoint a Nominating Committee, which committee shall present at least one name for each of the six elective offices of the Association.

(b) Active members shall have the privilege of presenting additional nominations from the floor before ballot is taken.

(c) Election shall be by ballot and in order to be declared elected, a nominee must secure a majority of all votes cast.

(d) In case an elective office, except President, is vacated during term of incumbent, the President with the advice and consent of the Executive Committee shall make an appointment for the unexpired term of office. In case the office of President is vacated during term of incumbent, the Vice-President shall succeed and serve as President for the remainder of the term.

*Section 4. Duties of officers*

(a) The President shall preside at all meetings and be executive head of the Association. He shall appoint the necessary committees for conducting the business of the Association.

(b) The Vice-President shall preside at meetings in the absence of the President, and assist him in the duties of his office. He shall also act as Chairman of the Executive Committee. Bills of the Association shall not be paid except with the approval of the Vice-President, and all checks issued shall be countersigned by the Vice-President.

(c) The Secretary shall keep a record of the minutes of the general meetings and carry on the general correspondence of the Association. He shall also maintain close contact with the local sections and carry on inter-sectional correspondence.

(d) The Treasurer shall collect all fees and moneys due the Association, and pay all bills by check, and shall record all such receipts and expenditures. Bills shall not be paid except with the approval of the Vice-President, and all checks issued shall be countersigned by the Vice-President. The Treasurer shall also keep the membership roster of the Association.

(e) The Editor-in-Chief of CEREAL CHEMISTRY shall, with the consent of the President, appoint the Associate and Assistant Editors as may be necessary, and the same with the Editor-in-Chief shall constitute the Editorial Staff of CEREAL CHEMISTRY. It shall be the duty of the Editorial Staff to select and prepare material for publication in the official organ of the Association.

(f) The Managing Editor shall make arrangements for the publication of CEREAL CHEMISTRY. He shall handle all business matters, including advertising, connected with the publication of the official organ of the Association.

*Section 5. Executive Committee*

(a) The President and the Chairman of the Executive Committee (Vice-President) shall jointly select three active members of the Association to act with them as an Executive Committee, two of whom shall be past Presidents of the Association.

(b) The President of the Association shall have the privilege of voting in meetings of the Executive Committee.

(c) The Executive Committee shall co-operate with the President in carrying on the business of the Association between meetings. The Executive Committee shall have power to control the policy of the Association between meetings, including finances of all Association activities.

*Section 6. Auditing Committee*

The President shall appoint three or more active members before each general meeting to act as an Auditing Committee. It shall be the duty of this committee to examine the books of the Treasurer and the books of CEREAL CHEMISTRY. Other

financial records of the Association also may be examined at the discretion of this Committee. The Auditing Committee shall report its findings to the Association. This committee, with the approval of the Executive Committee, may employ a certified accountant to audit these books.

*Section 7. Additional committees*

The President shall have power to appoint such additional committees as may be found necessary for the proper conduct of the business of the Association.

## Article V

### *Dues and Fees*

*Section 1. Application fees*

(a) The application fee for active membership shall be ten dollars, which shall include the first year's dues. The fee must accompany the application and will be returned in case application is rejected.

(b) The application fee is limited to active members.

*Section 2. Dues—active members*

(a) The dues of active members of this association shall be seven dollars per annum from January first to December thirty-first.

(b) Three dollars and fifty cents of the annual dues of active members shall constitute a subscription to CEREAL CHEMISTRY, and shall be set aside as such.

(c) Dues of active members are payable in advance, the membership card constituting a receipt for same.

*Section 3. Honorary members*

Honorary members shall be exempt from all dues and fees.

*Section 4. Corporation members*

The dues of corporation members shall be ten dollars per annum, from January first to December thirty-first. Said dues are payable in advance, and shall be allotted to the publication fund.

*Section 5. Delinquent members*

Annual dues are payable in advance to the Treasurer, and if not paid by March first of the current year, delinquents shall be dropped from membership, and their names removed from the mailing list of the Association.

*Section 6. Assessments*

Assessments not to exceed one year's dues may be levied in any one year when the current expenses of the Association make this necessary. The Treasurer may recommend the levy of such assessment which must be approved by the Executive Committee before becoming effective.

## Article VI

### *Meetings, Elections, and Privileges*

*Section 1. General meetings or conventions*

General meetings or conventions shall be held annually at such time and place as may be determined by the Executive Committee.

*Section 2. Quorum*

In all general meetings, an attendance of one-half of the active members of the Association registered at the meeting or convention shall constitute a quorum to transact business.

*Section 3. Term of office*

Officers of the Association shall be elected to serve for a term of one year or until their successors are installed.

*Section 4. Voting privilege*

Only active members of the Association shall be entitled to vote in meetings and in elections of officers of the Association.

*Section 5. Privileges of Honorary and Corporation members*

(a) Honorary members and representatives of corporation members shall have the privilege of attending all general meetings and in addition the privilege of the floor, but shall have no vote.

(b) Honorary and Corporation members shall be entitled to receive the regular publications of the Association and may have the privileges of membership in a local section.

## Article VII

### *Local Sections*

*Section 1.* Local organizations or clubs of cereal chemists upon application to the President and Executive Committee of the Association may be granted charters as local sections of the American Association of Cereal Chemists subject to the following provisions:

(a) All of the officers and at least three-fourths of the members of such organizations shall be active members of the American Association of Cereal Chemists.

(b) The elective officers of sections shall be Chairman, Vice-Chairman, Secretary, and Treasurer.

(c) Local sections shall have power to levy dues and assessments upon their members.

*Section 2.* In case of any dispute regarding territorial jurisdiction between sections, the matter shall be referred to the Executive Committee of the American Association of Cereal Chemists, their decision to be final.

*Section 3.* The President and Executive Committee of the American Association of Cereal Chemists may withdraw charters issued for failure to comply with constitutional provisions or other just cause. Such action shall not be taken until after full opportunity for a hearing shall have been afforded.

## Article VIII

### *Amendments*

*Section 1.* Amendments to this Constitution may be made at any general meeting. A two-thirds majority of the members present shall be necessary to carry.

*Section 2.* Amendments to this Constitution shall state the Article and Section amended, and shall be submitted in writing to the Secretary and in turn be submitted to the members by mail or through CEREAL CHEMISTRY at least three months prior to meeting at which vote is to be taken.

## NOTE

*In re* article by B. Sullivan, Cleo Near, and Guy H. Foley, "THE RÔLE OF THE LIPIDS IN RELATION TO FLOUR QUALITY," CEREAL CHEM. 13: 318-331 (1936), E. A. Fisher and C. R. Jones, of the Research Association of British Flour-Millers, St. Albans, Herts, England, have submitted the following comment:

"In a recent paper in your journal, Sullivan, Near, and Foley (1936) state: 'A few workers (Stockham (1920), Research Association of British Flour-Millers (1932)) have found impaired baking quality with ether-extracted flour when compared with the original flour.' This statement appears to be an inference from an Abstract published in another journal and is incorrect.

"Experiments carried out in the writers' laboratories prior to 1932 showed that oil extracted by means of either ethyl- or petrol-ether from flour, and particularly from low-grade flour, is a really first rate bread improver. It does not, however, follow that the ether-extracted flour is inferior in baking quality to the original unextracted flour. On the contrary, the ether-extracted flour shows markedly improved baking quality in several respects. The improvement is presumably due to some action of the ether on some flour constituents which are not removed. If the extracted oil (of course, after removal of the ether) is returned to the ether-extracted flour further improvement results; the bread from such flour is strikingly better in volume, texture, and spring of crumb than that from the original untreated flour."